FIFTY-FIRST ANNUAL REPORT

OF THE

Agricultural Experiment Station

OF THE

UNIVERSITY OF KENTUCKY

▼

PART II

Bulletins 378-388
Circular 49

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OF THE

Kentucky Agricultural Experiment Station

FOR THE YEAR 1938

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Kentucky
Agricultural Experiment Station

University of Kentucky

PHOSPHORUS CONTENT OF THE YOLK OF FRESH AND STORAGE EGGS

BULLETIN NO. 378

Lexington, Ky.

March, 1938

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Bulletin No. 378

Phosphorus Content of the Yolk of Fresh and Storage Eggs

By S. E. ERIKSON, R. E. BOYDEN, W. M. INSKO, JR., and J. HOLMES MARTIN

The phosphorus content of egg yolk is of interest both in human nutrition and in avian nutrition; in the latter because of its possible effect on fertility and hatchability. Since phosphorus is such an important constituent of all tissues, it is conceivable that the factors which affect activity of nerve and glandular tissues of the hen might also affect the content or the distribution, or both, of the phosphorus of the egg yolk.

It is a well established fact that a diet deficient in phosphorus or calcium results in hypocalcification of bones and decreased values for inorganic blood phosphorus and blood calcium, unless vitamin D or ultraviolet radiation either from the sun or from an artificial source is administered (1) (2) (3) (4) (5). That vitamin D may also have an effect on the phosphorus content of other tissues than bone is shown by Nicolaysen (6) who found a reduction of inorganic phosphorus and phosphagen in muscles and of inorganic phosphorus in liver and kidneys of rachitic rats. The phosphorus content of the milk of lactating animals seems less easily affected. For instance, Hess, Light, Frey and Gross (7) found that excessive amounts of irradiated ergosterol or irradiated yeast added to the ration of cows caused an increase in the phosphorus content of the milk, but that moderate amounts of the supplements did not. Jordan, Hart and Patten (8), on the other hand, found that variation in the phosphorus content of the ration influences the phosphorus concentration of the milk. Similar observations have been made on eggs. Irradiation of the hens, according to Hart, Steenbock and associates (9) did not affect the phosphorus content of the egg. Hughes and Payne (10), however, found that the phosphorus content of the egg is increased by the administration to the hens of both sunshine and ultraviolet irradi-

ation. They gave as the phosphorus content of yolks of eggs from hens kept inside away from light, 1.090 percent; from hens given sunshine, 1.160 percent; from hens given ultraviolet rays, 1.155 percent.

Variations in rations of the hens seem to have a tendency to affect phosphorus content of the yolks of eggs to a slight degree. Buckner, Martin and Peter (11) fed grit, oyster shell, limestone and rock phosphate as different sources of calcium. The phosphorus content of the eggs from hens given a calcium supplement was somewhat higher than from the lot fed dry mash without such a supplement. Values ranged from 0.44 percent P_2O_5 in the lot without any supplement to 0.50 percent in the lot on grit and oyster shell as well as in the lot on limestone. They found that the average amount of phosphorus as P_2O_5 in the content of the whole egg varied from 172 milligrams for the lot receiving no calcium supplement to 234 milligrams for the lot given grit and limestone. Cross (12) found that feeding inorganic phosphorus to the hen did not increase the phosphorus content of the egg. Carpiaux (13) says that the composition of the egg is variable and refers to the fact that phosphorus content of the yolk can be increased.

Altho good methods are not available at the present time for analysis of all the fractions of phosphorus that probably exist in egg yolk, it was considered that further information on the total acid-soluble and the inorganic phosphorus might add to an understanding of phosphorus metabolism. Chapin and Powick (14) have found that a change in ratio occurs between inorganic and total acid-soluble phosphorus as the age of the egg increases. They report that the inorganic phosphorus of day-old eggs is from 3.06 percent to 3.67 percent of the total phosphorus, while in eggs 187 days old it is 4.24 percent to 4.44 percent. Pine (16) finds similar changes occurring. He gives, for one-day old eggs, 93.9 to 111.9 milligrams of acid-soluble P_2O_5 per 100 grams of dry egg yolk and for eleven months old eggs 117.7 to 141.2 milligrams.

Information as to the effect of the hen's management, dietary and otherwise, on the phosphorus content of the egg is comparatively meager. Because it is of value to know what factors, if any, may affect the phosphorus content and to what extent, a study was

made in this laboratory on the acid-soluble inorganic phosphorus, the total acid-soluble phosphorus and the total phosphorus of yolks of fresh and storage eggs produced under controlled conditions. The investigation is part of a project*, the purpose of which is to study some of the factors that may affect the nutritive quality of eggs.

The general procedure has been given in a previous paper (15). It suffices to say here, therefore, that the hens were kept in three pairs of pens, as follows:

First Pair. Confined to house, no direct sunshine, only sunlight received thru common window glass.
Pen 1—No cod liver oil. Pen 2—2% cod liver oil.

Second Pair. Confined to house and wire-screened, wire-floored sun porch.
Pen 3—No cod liver oil. Pen 4—2% cod liver oil.

Third Pair. Allowed range of bluegrass yard.
Pen 5—No cod liver oil. Pen 6—2% cod liver oil.

METHODS

Eggs from 6 hens in each pen were collected daily for 5 periods of 10 days each. During a sixth period of 30 days, eggs from the same 6 hens were collected and placed in cold storage each evening. The precipitation of the yolk of fresh eggs by trichloracetic acid and filtration were carried out as soon as possible, usually within two hours after they were laid and never more than six. Each egg was broken against the edge of a beaker and the white and yolk separated. A portion of yolk for the acid-soluble phosphorus determinations was weighed out as quickly as possible and mixed with 5ml. of distilled water. Forty ml. of 10 percent trichloracetic acid were then added with constant stirring and the mixture was filtered. The filtrate was stoppered and the acid-soluble phosphorus determinations made according to the method of Fiske and Subbarow (17). For total phosphorus a weighed portion of the yolk was dried slowly, beginning at a temperature of 40°C. and increasing gradually to 70°C. It was then burned in a muffle furnace to a white ash. The ash was dissolved in about 50ml. of

* Ky. Agr. Exp. Sta. Bull. Nos. 335, 337, and 342.

hydrochloric acid, evaporated to dryness, taken up in 50ml. of hydrochloric acid, transferred to a 100ml. volumetric flask and diluted to volume. One to two ml. of the solution were taken for the determination of phosphorus by the Fiske and Subbarow method (17). The determinations were made in duplicate on each yolk.

RESULTS

Protocols of the detailed results of the analyses are filed at the Kentucky Agricultural Experiment Station Library. The figures for inorganic phosphorus and total acid-soluble phosphorus are given for the yolks of 183 fresh eggs and for the yolks of 154 storage eggs. The total phosphorus is given for the yolks of 245 fresh eggs and the yolks of 307 storage eggs. Mean values were calculated for the yolks of all the eggs laid by each hen. Mean values were also calculated for each pen. Since the chief interest lies in whether different pen treatment is reflected in actual differences in phosphorus content of the yolk, only the tables for the mean values are given in this paper.

THE YOLK OF FRESH EGGS

Inorganic Phosphorus. It was interesting to find that the day to day variations, in the egg yolks of individual hens, as appears in the detailed data, were as large as the differences between the averages for each hen. It was also found that the mean values for each hen showed as great differences as those between the means for each pen, Table 1. The range, however, within which the variations occurred in each pen, is not the same. This is brought out in the pen averages. Some overlapping is found, as would be expected in biological material, and yet no hen in pen 6, which had all three vitamin D supplements, had as low a mean value of inorganic phosphorus in egg yolk as the average found in pen 1, Table 2, which had no vitamin D supplement. The lowest mean values per hen are found in pens 1 and 2, in which the birds were kept in confinement without bluegrass or sunshine.

The range of mean values per hen in pen 1 is from 2.84 to 3.82 milligrams per yolk. The range in pen 6 is from 3.15 to 4.39 milligrams per total yolk. Expressed in milligrams percent*, the out-

* Milligrams per 100 grams of yolk.

side limits of variation are not found in the same hens as when the value is expressed in milligrams of phosphorus per yolk. The figures are 17.33 to 25.49 milligrams percent for pen 1 and 21.76 to 31.58 milligrams percent for pen 6. The reason for the difference in range of values when expressed the two ways is probably to be found in the difference in the size of yolks.

The means of the values per hen indicate that a vitamin D supplement tends to increase the inorganic phosphorus content of the egg yolk. When the supplement is cod liver oil alone, the difference amounts to 4.75 ± 0.89 milligrams percent, Table 2. When the supplement is sunshine alone, the difference is 5.05 ± 0.77 milligrams percent. Sunshine plus bluegrass gives a difference of 4.26 ± 0.66 milligrams percent, while all three supplements, cod liver oil, sunshine and bluegrass give a difference of 5.59 ± 0.72 milligrams percent. As will be seen from the ratio of the difference to the probable error of the difference, these results are all significant. Any one of the vitamin D supplements alone seems to have practically as much effect as any two or as all three together.

The literature contains very little on inorganic phosphorus in egg yolk. According to Fiske and Subbarow (17) all the inorganic phosphorus is soluble in the aqueous acid solution. Masai and Fukutomi (18) found an average of 10.1 milligrams percent for whole egg, a value that is similar to the ones in Table 13, if it is assumed that the yolk contains most of the phosphorus of the egg and that the yolk comprises approximately 35 percent of the whole egg.

Total Acid-Soluble Phosphorus. It is not known exactly what the total acid-soluble phosphorus includes. Peters and Van Slyke (19) speaking of blood, say that the non-lipoidal organic phosphorus esters, including phospho-creatine, all appear to be soluble in aqueous acid solutions and together with the inorganic phosphorus make up the so-called acid-soluble phosphorus. Whether this applies also to egg yolk has not been brought out by any investigations up to the present time. McClendon (20) centrifuged amphibian eggs and found that the association between phosphoprotein and lipoid was the only one that centrifuging could not

break, indicating a close lecitho-vitellin combination. The values for total acid-soluble phosphorus given by Masai and Fukutomi (18), who used an entirely different method of extraction from that of Fiske and Subbarow (17), are much higher than the ones found in this investigation. This may indicate a possibility that the trichloracetic acid of the Fiske-Subbarow method may extract only a part of the non-lipoidal organic phosphorus. Whatever phosphorus that organic fraction does include, however, seems to be less affected by the vitamin D supplements than the inorganic phosphorus. The lowest mean value per hen, 21.26 milligrams percent, is, nevertheless, found in pen 1 where no vitamin D supplement was given, and the highest mean value per hen, 38.44 milligrams percent, is found in pen 6, where all three supplements were given, Table 3. The lowest mean value per hen is 27.08 ± 0.70 milligrams percent and is not that of pen 1 but is that of pen 2, the vitamin D supplement for which was cod liver oil, Table 4. The highest mean value per pen 31.36 ± 0.59, is found in pen 6.

Total Phosphorus. Most of the phosphorus of the egg yolk does not occur as the acid-soluble fraction, Tables 5 and 6. The range of mean pen values is from 477.4 ± 8.92 milligrams percent for pen 2 to 521.5 ± 5.87 milligrams percent for pen 5, Table 6. Presumably the greater part of the total phosphorus is lipoid phosphorus and is not affected to any practical extent by vitamin supplements. Statistical analysis of the figures does not indicate any significant difference between pens that do and do not get cod liver oil, sunshine or bluegrass or a combination of any two or of all three. More investigations have been made on total phosphorus of eggs than on the fractions but in most cases the number of eggs analyzed was very small. Juckenack (21) gives 0.559 percent in egg yolk. Lebbin's (22) value of 0.625 was found in six yolks; Malcolm's (23) of 0.620 in three, and also 0.655 in two yolks; van Meurs' (24) of 0.589 in ten yolks and 0.577 in six yolks. Mitchell's (25) sampling was much wider since he used 42 samples of 24 eggs each, selected from eggs shipped from thirty-eight states. The value he gives, therefore, of 0.603 percent may be considered a valid average for market eggs. None of these values give information on the effect of different treatments.

THE YOLK OF STORAGE EGGS

Storage conditions were not perfect. The storage plant had to be repaired after the eggs had been put in and, therefore, they were moved across the city to another storage plant. After a total of twelve months storage, they were taken out for analysis. Some of them showed distinct deterioration to the extent that it was impossible to get the yolk out intact and the data, therefore, are incomplete.

The inorganic phosphorus of the yolks of storage eggs follows the same trend as that of the yolks of fresh eggs, in that the effect of any one of the three vitamin D supplements is towards an increase of the phosphorus in the yolk, Tables 7 and 8. The trends of the total acid-soluble phosphorus, Tables 9 and 10, and the total phosphorus do not so clearly follow those of the yolks of fresh eggs. Tables 11 and 12.

Table 13 shows that the ratio of the total acid-soluble to total phosphorus is consistently greater in the yolks of storage eggs than in the fresh. This may indicate a conversion of phosphatides to some other phosphorus-containing substance that is acid soluble. That the substance may be inorganic phosphorus appears possible from the ratio of inorganic phosphorus to total phosphorus. This suggests the statement of Peters and Van Slyke (19) who, in discussing blood phosphorus, say that phosphatides may act as, at least, potential sources of inorganic phosphates.

In all the lots the total phosphorus was less in storage than in fresh egg yolks. Wiley (26) found a similar decrease as did also Mitchell (25). Wiley's value for fresh egg yolk was 0.571 and for storage, 0.562 percent. Mitchell's values were 0.603 for fresh and 0.547 for storage. Such differences in total phosphorus between fresh and storage egg yolks are due, in all probability, to a shift of water from the white to the yolk.

SUMMARY

Inorganic and total acid-soluble phosphorus were determined in the yolks of 183 fresh and 154 storage eggs. The total phosphorus was determined on the yolks of 245 fresh and 307 storage eggs. The eggs were produced under controlled conditions to test the

effect of administration to the hens of cod liver oil, sunshine and bluegrass and also of two of the three given together and of all three given together. The results indicate that any one of the vitamin D supplements tend to increase the inorganic phosphorus and that all three together have a more marked effect than any one by itself. While the total acid-soluble phosphorus and the total phosphorus show tendencies towards a like effect, it is neither so marked nor so consistent.

In the yolks of storage eggs the total acid-soluble phosphorus increases and the total phosphorus decreases. The changes that occur in the proportions of the phosphorus fractions do not seem to be due to the vitamin D supplements. The ratio of total acid-soluble to the total phosphorus is greater in storage than in fresh egg yolks. It is an effect that is consistent in all the pens and, therefore, seems to have nothing to do with vitamin D supplements.

Interpretation of results will be taken up in the final paper of this study in which the correlations will be considered between the constituents of the egg yolks studied and fertility and hatchability of the eggs as well as the relation to known requirements of human nutrition.

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Table 1. Average inorganic phosphorus in the yolk of fresh eggs from each hen.

Pen No.	Treatment of the hens	Hen No.	Per yolk	Per 100g. of yolk
Confined, Sunshine Thru Ordinary Glass			mg.	mg.
1	No cod liver oil	386	2.84	18.44
		387	3.03	17.33
		391	3.26	19.49
		392	——	——
		395	——	——
		402	3.82	25.49
2	With cod liver oil	410	3.74	22.33
		411	2.88	20.57
		421	——	——
		426	3.79	24.81
		427	4.58	27.98
		428	4.08	25.02
Confined, Direct Sunshine				
3	No cod liver oil	441	4.60	27.12
		448	3.68	22.82
		453	5.02*	30.31*
		456	3.68	20.99
		457	4.52	25.28
		461	4.41	27.63
4	With cod liver oil	466	4.16	22.53
		467	3.73	22.37
		476	——	——
		482	——	——
		486	4.32	29.30
		488	3.86	23.62
Bluegrass Range, Sunshine				
5	No cod liver oil	501	3.61	22.95
		502	3.51	21.67
		508	3.78	26.19
		514	4.05	22.77
		519	3.59	23.58
		521	5.00	27.65
6	With cod liver oil	530	4.32	31.58
		541	4.04	25.40
		544	3.86	24.04
		549	3.15	21.76
		550	4.27	27.70
		554	4.39	25.31

*Single determination.

Table 2. The difference of the means of inorganic phosphorus per 100 grams of yolk of fresh eggs.

Pen No.	Treatment of the hens	No. obs.	Means *	Difference	D P. E. diff.
Confined, Sunshine Thru Ordinary Glass			mg.	mg.	**
1	No cod liver oil	15	19.85±0.60		
2	With cod liver oil	24	24.60±0.66	4.75±0.89	5.3
Confined, Direct Sunshine					
3	No cod liver oil	30	24.90±0.49		
4	With cod liver oil	25	23.63±0.41	1.27±0.64	2.0
Bluegrass Range, Sunshine					
5	No cod liver oil	43	24.11±0.29		
6	With cod liver oil	46	25.44±0.40	1.33±0.49	2.7
No Cod Liver Oil					
1	Confined, sunshine thru ordinary glass	15	19.85±0.60		
3	Confined, direct sunshine	30	24.90±0.49	5.05±0.77	6.5
1	Confined, sunshine thru ordinary glass	15	19.85±0.60		
5	Bluegrass range, sunshine	43	24.11±0.29	4.26±0.66	6.4
3	Confined, direct sunshine	30	24.90±0.49		
5	Bluegrass range, sunshine	43	24.11±0.29	0.79±0.57	1.4
With Cod Liver Oil					
2	Confined, sunshine thru ordinary glass	24	24.60±0.66		
4	Confined, direct sunshine	25	23.63±0.41	0.97±0.78	1.2
2	Confined, sunshine thru ordinary glass	24	24.60±0.66		
6	Bluegrass range, sunshine	46	25.44±0.40	0.84±0.77	1.1
4	Confined, direct sunshine	25	23.63±0.41		
6	Bluegrass range, sunshine	46	25.44±0.40	1.81±0.57	3.2
Extreme Conditions					
1	No vitamin D supplement, no cod liver oil, confined	15	19.85±0.60		
6	With the vitamin D supplements, i. e. cod liver oil, sunshine and bluegrass range	46	25.44±0.40	5.59±0.72	7.5

*Obtained by averaging the values for all yolks of each pen.

**A value of 3.0 indicates that there is a significant difference. As this value increases above 3.0 its significance increases.

Table 3. Average total acid-soluble phosphorus in the yolk of fresh eggs from each hen.

Pen No.	Treatment of the hens	Hen No.	Per yolk	Per 100g. of yolk
	Confined, Sunshine Thru Ordinary Glass		mg.	mg.
1	No cod liver oil	386	3.29	21.26
		387	5.67	33.16
		391	4.47	26.72
		392	——	——
		395	——	——
		402	5.40	36.24
2	With cod liver oil	410	4.23	25.12
		411	3.16	22.57
		421	——	——
		426	4.23	28.31
		427	4.71	30.07
		428	4.54	27.95
	Confined, Direct Sunshine			
3	No cod liver oil	441	5.48	32.28
		448	5.07	31.31
		453	4.76*	28.75*
		456	3.95	22.50
		457	5.25	29.39
		461	5.10	32.00
4	With cod liver oil	466	5.04	27.25
		467	4.60	27.69
		476	——	——
		482	——	——
		486	4.37	30.08
		488	4.76	29.17
	Bluegrass Range, Sunshine			
5	No cod liver oil	501	3.98	25.22
		502	4.52	27.89
		508	4.17	29.08
		514	4.74	26.66
		519	4.73	31.14
		521	6.09	33.71
6	With cod liver oil	530	5.33	38.44
		541	4.90	30.78
		544	5.03	31.35
		549	3.98	27.54
		550	4.72	30.63
		554	5.83	33.14

*Single determination.

Table 4. The difference of the means of total acid-soluble phosphorus per 100 grams of yolk of fresh eggs.

Pen No.	Treatment of the hens	No. obs.	Means *	Difference	D / P. E. diff.
Confined, Sunshine Thru Ordinary Glass			mg.	mg.	**
1	No cod liver oil	15	27.48±1.20		
2	With cod liver oil	24	27.08±0.70	0.40±1.39	0.3
Confined, Direct Sunshine					
3	No cod liver oil	30	28.92±0.64		
4	With cod liver oil	25	28.45±0.77	0.47±1.00	0.5
Bluegrass Range, Sunshine					
5	No cod liver oil	43	28.15±0.36		
6	With cod liver oil	46	31.36±0.59	3.21±0.70	4.6
No Cod Liver Oil					
1	Confined, sunshine thru ordinary glass	15	27.48±1.20		
3	Confined, direct sunshine	30	28.92±0.63	1.44±1.36	1.1
1	Confined, sunshine thru ordinary glass	15	27.48±1.20		
5	Bluegrass range, sunshine	43	28.15±0.36	0.67±1.26	0.5
3	Confined, direct sunshine	30	28.92±0.63		
5	Bluegrass range, sunshine	43	28.15±0.36	0.77±0.73	1.1
With Cod Liver Oil					
2	Confined, sunshine thru ordinary glass	24	27.08±0.70		
4	Confined, direct sunshine	25	28.45±0.77	1.37±1.04	1.3
2	Confined, sunshine thru ordinary glass	24	27.08±0.70		
6	Bluegrass range, sunshine	46	31.36±0.59	4.28±0.92	4.7
4	Confined, direct sunshine	25	28.45±0.77		
6	Bluegrass range, sunshine	46	31.36±0.59	2.91±0.97	3.0
Extreme Conditions					
1	No vitamin D supplement, no cod liver oil, confined	15	27.48±1.20		
6	With the vitamin D supplements, i. e. cod liver oil, sunshine and bluegrass range	46	31.36±0.59	3.88±1.34	2.9

*Obtained by averaging the values for all yolks of each pen.
**A value of 3 or larger is considered significant.

Table 5. Average of the total phosphorus in the yolk of fresh eggs from each hen.

Pen No.	Treatment of the hens	Hen No.	Per yolk	Per 100g. yolk	Percent of the ash
Confined, Sunshine Thru Ordinary Glass			mg.	mg.	
1	No cod liver oil	386	53.49	359	24.00
		387	81.02	493	31.63
		391	88.41	521	33.88
		392	83.50	491	30.44
		395	——	——	——
		402	84.23	522	32.91
2	With cod liver oil	410	85.55	520	31.78
		411	66.39*	497*	32.16*
		421	74.79	499	31.53
		426	74.92	475	28.54
		427	62.48	408	25.52
		428	72.77	450	28.48
Confined, Direct Sunshine					
3	No cod liver oil	441	87.21	521	31.32
		448	79.79	486	32.39
		453	85.85	522	31.01
		456	84.79	485	31.13
		457	91.86	511	30.17
		461	91.90	526	32.33
4	With cod liver oil	466	90.37	489	32.70
		467	83.12	503	31.49
		476	——	——	——
		482	82.01	500	32.00
		486	69.52	472	29.79
		488	87.86	540	33.12
Bluegrass Range, Sunshine					
5	No cod liver oil	501	76.95	486	30.26
		502	82.94	514	31.78
		508	77.62	530	32.47
		514	91.52	501	29.28
		519	78.09	515	31.98
		521	94.20	552	32.03
6	With cod liver oil	530	62.65	468	28.11
		541	80.63	506	31.44
		544	70.43	452	28.47
		549	61.87	398	24.36
		550	77.02	496	28.82
		554	83.44	486	30.04

*Single determination.

Table 6. The difference of the means of total phosphorus per 100 grams of yolk of fresh eggs.

Pen No.	Treatment of the hens	No. obs.	Means *	Difference	D P. E. diff.
Confined, Sunshine Thru Ordinary Glass			mg.	mg.	**
1	No cod liver oil	23	484.2±12.06		
2	With cod liver oil	38	477.4± 8.92	6.8±15.00	0.5
Confined, Direct Sunshine					
3	No cod liver oil	33	507.8± 5.00		
4	With cod liver oil	31	503.8± 4.84	4.0± 6.95	0.6
Bluegrass Range, Sunshine					
5	No cod liver oil	50	521.5± 5.87		
6	With cod liver oil	70	484.7± 5.72	36.8± 8.20	4.5
No Cod Liver Oil					
1	Confined, sunshine thru ordinary glass	23	484.2±12.06		
3	Confined, direct sunshine	33	507.8± 5.00	23.6±13.05	1.8
1	Confined, sunshine thru ordinary glass	23	484.2±12.06		
5	Bluegrass range, sunshine	50	521.5± 5.87	37.3±13.41	2.8
3	Confined, direct sunshine	33	507.8± 5.00		
5	Bluegrass range, sunshine	50	521.5± 5.87	13.7± 7.71	1.8
With Cod Liver Oil					
2	Confined, sunshine thru ordinary glass	38	477.4± 8.92		
4	Confined, direct sunshine	31	503.8± 4.84	26.4±10.15	2.6
2	Confined, sunshine thru ordinary glass	38	477.4± 8.92		
6	Bluegrass range, sunshine	40	484.7± 5.72	7.3±10.60	0.7
4	Confined, direct sunshine	31	503.8± 4.84		
6	Bluegrass range, sunshine	40	484.7± 5.72	19.1± 7.50	2.6
Extreme Conditions					
1	No vitamin D supplement, no cod liver oil, confined	23	484.2±12.06		
6	With the vitamin D supplements, i. e. cod liver oil, sunshine and bluegrass range	70	484.7± 5.72	0.5±13.3	0.0

*Obtained by averaging the values for all yolks of each pen.
**A value of 3 or larger is considered significant.

Table 7. Average of the inorganic phosphorus in the yolk of storage eggs from each hen.

Pen No.	Treatment of the hens	Hen No.	Per yolk	Per 100g. of yolk
	Confined, Sunshine Thru Ordinary Glass		mg.	mg.
1	No cod liver oil	386	3.12*	14.74*
		387	——	——
		391	2.93	18.04
		392	5.76*	21.15*
		395	——	——
		402	3.70*	24.85*
2	With cod liver oil	410	3.83	22.23
		411	——	——
		421	3.25	20.08
		426	3.75	21.50
		427	3.84	21.55
		428	4.06	23.83
	Confined, Direct Sunshine			
3	No cod liver oil	441	4.85	26.07
		448	——	19.42
		453	——	——
		456	4.79	22.84
		457	4.82	23.85
		461	——	——
4	With cod liver oil	466	4.42	21.10
		467	3.83	21.69
		476	——	——
		482	5.03	23.45
		486	4.15	24.07
		488	3.61	20.75
	Bluegrass Range, Sunshine			
5	No cod liver oil	501	4.23	22.07
		502	4.09	24.42
		508	4.13	27.03
		514	4.60	22.28
		519	4.08	22.41
		521	5.70	28.77
6	With cod liver oil	530	3.95*	28.88*
		541	3.80	20.69
		544	3.94	23.92
		549	3.88	22.80
		550	4.40	27.22
		554	4.17	22.85

*Single determination.

Table 8. The difference of the means of the inorganic phosphorus per 100 grams of yolk of storage eggs.

Pen No.	Treatment of the hens	No. obs.	Means *	Difference	D P. E. diff.
Confined, Sunshine Thru Ordinary Glass			mg.	mg.	**
1	No cod liver oil	7	18.98±1.08		
2	With cod liver oil	21	22.00±0.25	3.02±1.11	2.7
Confined, Direct Sunshine					
3	No cod liver oil	23	24.05±0.67		
4	With cod liver oil	26	21.59±0.42	2.46±0.79	3.1
Bluegrass Range, Sunshine					
5	No cod liver oil	43	24.53±0.32		
6	With cod liver oil	34	24.13±0.33	0.40±0.46	0.9
No Cod Liver Oil					
1	Confined, sunshine thru ordinary glass	7	18.98±1.08		
3	Confined, direct sunshine	23	24.05±0.67	5.07±1.27	4.0
1	Confined, sunshine thru ordinary glass	7	18.98±1.08		
5	Bluegrass range, sunshine	43	24.53±0.32	5.55±1.12	5.0
3	Confined, direct sunshine	23	24.05±0.67		
5	Bluegrass range, sunshine	43	24.53±0.32	0.48±0.75	0.6
With Cod Liver Oil					
2	Confined, sunshine thru ordinary glass	21	22.00±0.25		
4	Confined, direct sunshine	26	21.59±0.42	0.41±0.49	0.8
2	Confined, sunshine thru ordinary glass	21	22.00±0.25		
6	Bluegrass range, sunshine	34	24.13±0.33	2.13±0.42	5.1
4	Confined, direct sunshine	26	21.59±0.42		
6	Bluegrass range, sunshine	34	24.13±0.33	2.54±0.53	4.8
Extreme Conditions					
1	No vitamin D supplement, no cod liver oil, confined	7	18.98±1.08		
6	With the vitamin D supplements, i. e. cod liver oil, sunshine and bluegrass range	34	24.13±0.33	5.15±1.58	3.4

*Obtained by averaging the values for all yolks of each pen.
**A value of 3 or larger is considered significant.

Table 9. Average of the total acid-soluble phosphorus in the yolk of storage eggs from each hen.

Pen No.	Treatment of the hens	Hen No.	Per yolk	Per 100g. of yolk
			mg.	mg.
Confined, Sunshine Thru Ordinary Glass				
1	No cod liver oil	386	4.04*	19.07*
		387	——	——
		391	4.15	25.42
		392	6.99*	25.67*
		395	——	——
		402	4.62*	31.09*
2	With cod liver oil	410	5.65	32.96
		411	——	——
		421	4.38	27.06
		426	5.26	30.48
		427	5.11	30.67
		428	5.52	32.11
Confined, Direct Sunshine				
3	No cod liver oil	441	6.46	35.03
		448	——	23.91
		453	——	——
		456	5.26	27.45
		457	7.67	37.44
		461	——	——
4	With cod liver oil	466	6.39	30.50
		467	5.23	29.82
		476	——	——
		482	——	32.73
		486	4.51	26.15
		488	7.70	41.78
Bluegrass Range, Sunshine				
5	No cod liver oil	501	9.09	35.13
		502	6.97	38.25
		508	5.68	36.53
		514	6.24	29.93
		519	5.84	31.66
		521	8.75	45.30
6	With cod liver oil	530	4.92*	35.93*
		541	5.29	29.60
		544	5.94	36.25
		549	5.63	33.25
		550	6.01	37.18
		554	6.07	33.71

*Single determination.

Table 10. The difference of the means of total acid-soluble phosphorus per 100 grams of yolk of storage eggs.

Pen No.	Treatment of the hens	No. obs.	Means *	Difference	D P. E. diff.
Confined, Sunshine Thru Ordinary Glass			mg.	mg.	**
1	No cod liver oil	7	25.35±1.65		
2	With cod liver oil	21	31.03±0.64	5.68±1.77	3.2
Confined, Direct Sunshine					
3	No cod liver oil	23	33.07±1.07		
4	With cod liver oil	26	32.95±1.25	0.12±1.65	0.1
Bluegrass Range, Sunshine					
5	No cod liver oil	43	35.96±1.08		
6	With cod liver oil	34	33.76±0.61	2.20±1.24	1.8
No Cod Liver Oil					
1	Confined, sunshine thru ordinary glass	7	25.35±1.65		
3	Confined, direct sunshine	23	33.07±1.07	7.72±1.97	3.9
1	Confined, sunshine thru ordinary glass	7	25.35±1.65		
5	Bluegrass range, sunshine	43	35.96±1.08	10.61±1.97	5.4
3	Confined, direct sunshine	23	33.07±1.07		
5	Bluegrass range, sunshine	43	35.96±1.08	2.89±1.52	1.9
With Cod Liver Oil					
2	Confined, sunshine thru ordinary glass	21	31.03±0.64		
4	Confined, direct sunshine	26	32.95±1.26	1.92±1.41	1.4
2	Confined, sunshine thru ordinary glass	21	31.03±0.64		
6	Bluegrass range, sunshine	34	33.76±0.61	2.73±0.88	3.1
4	Confined, direct sunshine	26	32.95±1.25		
6	Bluegrass range, sunshine	34	33.76±0.61	0.81±1.39	0.6
Extreme Conditions					
1	No vitamin D supplement, no cod liver oil, confined	7	25.35±1.65		
6	With the vitamin D supplements, i. e. cod liver oil, sunshine and bluegrass range	34	33.76±0.61	8.41±1.76	4.8

*Obtained by averaging the values for all yolks of each pen.
**A value of 3 or larger is considered significant.

Table 11. Average of the total phosphorus in the yolk of storage eggs from each hen.

Pen No.	Treatment of the hens	Hen No.	Per yolk	Per 100g. yolk	Percent of the ash
	Confined, Sunshine Thru Ordinary Glass		mg.	mg.	
1	No cod liver oil	386	65.23	440	29.31
		387	54.09	404	25.07
		391	71.52	425	26.48
		392	97.88*	414*	28.62*
		395	——	——	——
		402	70.04	412	21.86
2	With cod liver oil	410	78.81	447	25.73
		411	72.88*	412*	——
		421	73.31*	433*	25.55*
		426	76.19	443	25.57
		427	74.91	433	26.67
		428	78.86	435	27.19
	Confined, Direct Sunshine				
3	No cod liver oil	441	81.40	459	26.55
		448	74.54	374	23.29
		453	——	——	——
		456	78.12	405	26.11
		457	87.42	445	25.22
		461	65.94*	427*	23.65*
4	With cod liver oil	466	86.09	421	26.58
		467	64.55	442	26.25
		476	——	——	——
		482	79.78	436	26.86
		486	69.70	369	27.36
		488	78.56	461	26.87
	Bluegrass Range, Sunshine				
5	No cod liver oil	501	70.90	466	27.55
		502	75.35	468	27.76
		508	72.16	469	25.76
		514	89.18	429	25.26
		519	81.53	460	28.22
		521	84.47	458	26.77
6	With cod liver oil	530	67.42	464	26.32
		541	72.84	438	26.07
		544	74.81	451	25.88
		549	76.61	448	28.61
		550	74.27	474	22.60
		554	82.09	464	27.69

*Single determination.

Table 12. The difference of the means of total phosphorus per 100 grams of yolk of storage eggs.

Pen No.	Treatment of the hens	No. obs.	Means *	Difference	D P. E. diff.
Confined, Sunshine Thru Ordinary Glass			mg.	mg.	**
1	No cod liver oil	19	419.1±8.23		
2	With cod liver oil	44	436.6±5.17	17.5± 9.72	1.8
Confined, Direct Sunshine					
3	No cod liver oil	46	430.2±5.87		
4	With cod liver oil	49	440.7±5.05	10.5± 7.74	1.4
Bluegrass Range, Sunshine					
5	No cod liver oil	86	456.8±3.81		
6	With cod liver oil	63	456.2±4.60	0.6± 5.97	0.1
No Cod Liver Oil					
1	Confined, sunshine thru ordinary glass	19	419.1±8.23		
3	Confined, direct sunshine	46	430.2±5.87	11.1±10.11	1.1
1	Confined, sunshine thru ordinary glass	19	419.1±8.23		
5	Bluegrass range, sunshine	86	456.8±3.81	37.7± 9.07	4.2
3	Confined, direct sunshine	46	430.2±5.87		
5	Bluegrass range, sunshine	86	456.8±3.81	26.6± 6.99	3.8
With Cod Liver Oil					
2	Confined, sunshine thru ordinary glass	44	436.6±5.17		
4	Confined, direct sunshine	49	440.7±5.05	4.1± 7.23	0.6
2	Confined, sunshine thru ordinary glass	44	436.6±5.17		
6	Bluegrass range, sunshine	63	456.2±4.60	19.6± 6.93	2.8
4	Confined, direct sunshine	49	440.7±5.05		
6	Bluegrass range, sunshine	63	456.2±4.60	15.5± 6.83	2.3
Extreme Conditions					
1	No vitamin D supplement, no cod liver oil, confined	19	419.1±8.23		
6	With the vitamin D supplements, i. e. cod liver oil, sunshine and bluegrass range	66	456.2±4.60	37.1± 9.43	3.9

*Obtained by averaging the values for all yolks of each pen.
**A value of 3 or larger is considered significant.

Table 13. Average phosphorus content of egg yolk.

Pen No.	Total Per 100g. yolk	Acid soluble Per 100g. yolk	Acid soluble Percent of the total	Inorganic Per 100g. yolk	Inorganic Percent of the total
Fresh Eggs					
	mg.	mg.		mg.	
1	484	27.48	5.68	19.85	4.10
2	477	27.08	5.67	24.60	5.15
3	508	28.92	5.70	24.90	4.90
4	504	28.45	5.65	23.63	4.69
5	522	28.15	5.40	24.11	4.62
6	485	31.36	6.47	25.44	5.25
Storage Eggs					
	mg.	mg.		mg.	
1	419	25.35	6.05	18.98	4.53
2	437	31.03	7.11	22.00	5.04
3	430	33.07	7.69	24.05	5.59
4	441	32.95	7.48	21.59	4.90
5	457	35.96	7.87	24.53	5.37
6	456	33.76	7.40	24.13	5.29

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Agricultural Experiment Station

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SOIL MANAGEMENT AND FERTILIZATION FOR TOBACCO

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Bulletin No. 379

SOIL MANAGEMENT AND FERTILIZATION FOR TOBACCO

By GEO. ROBERTS, E. J. KINNEY and J. F. FREEMAN

INTRODUCTION

The physical and chemical properties of the soil, variety of tobacco, spacing of the plants, topping and suckering practices, and method of curing are some of the factors that give to any type of tobacco the common characteristics which distinguish it from other types. Within the type, however, both yield and quality of leaf are determined very largely by the condition of the soil upon which the crop is grown. This is perhaps true of tobacco in a much greater degree than of any other common farm crop. It is of the greatest importance, therefore, to know what natural soil conditions are necessary to produce large percentages of the higher-priced grades of leaf in each type of tobacco and to determine the best methods of soil management and fertilizer usage to increase yields and improve quality.

The degree of acidity of the soil and the amount of nitrogen available at different stages of growth are both of particular importance in determining yield and quality of tobacco. The use of large amounts of liming materials often affects both yield and quality adversely because of the greater prevalence of certain tobacco diseases on heavily limed land, particularly root rot and frenching. Too heavy liming also tends to darken Burley and to make the leaf of dark tobacco rough and coarse.

Tobacco requires large supplies of nitrogen to make good yields, but the amounts available at certain stages of growth seem to determine quality to a marked degree. This is especially true of White Burley. Rapid growth in the early part of the growing season is necessary to produce the thin, smooth, colory grades of White Burley which now command the highest prices. Early rapid growth occurs only when the soil supplies large amounts of available nitrogen. Later, however, too much available nitrogen delays ma-

turity, which permits the leaves to thicken, and thick leaves usually cure dark. Apparently the organic matter in virgin soils or in old bluegrass sod land of high fertility furnishes available nitrogen in more nearly the necessary amounts at the proper time to produce choice Burley than any other kind of organic matter, or than can be accomplished by the use of nitrogen fertilizers. This is because the nitrification of organic matter is so greatly influenced by weather conditions. Weather conditions favorable for the growth of tobacco are favorable for nitrification, while weather conditions that retard the growth of tobacco check nitrification. Thus, available nitrogen varies largely with the requirements of the crop. Some kinds of organic matter—for example, that of old timothy sods—nitrify slowly and furnish too little for a rapid early growth of Burley. Later it may supply too much, and thus delay maturity. Burley following the turning under of a large amount of legumes often matures slowly, also, indicating an oversupply of nitrogen in late summer. Little is known about the value of other kinds of grass sods, altho in most instances orchard grass sods give at least a fair quality of Burley.

It should not be assumed that the superior quality of tobacco produced on old bluegrass sod land is due entirely to nitrogen supply. The physical condition of soils kept in bluegrass pasture, or any other kind of grass pasture, for that matter, is usually better than in other cropping systems, and this doubtless is important in determining the quality of Burley. Tobacco free from disease obviously makes a better yield and a better quality.

The dark tobaccos, including both the air-cured and fired types, are not so exacting in their soil requirements as Burley. In these types of tobacco the leaf characteristics most desired are good size, smooth finish, and very heavy body. These characteristics are most likely to be obtained where the crop grows at a moderate rate thruout the season and matures slowly. Obviously, soil conditions that furnish nitrogen in rather uniform and moderate amounts during the entire period of growth, or at least until the crop is practically mature, are most favorable for producing good dark leaf. The best dark tobacco soils are more retentive of moisture than good Burley soils; hence they are somewhat "colder," and nitrification is therefore less rapid. A content of organic matter that would supply too much nitrogen in the best Burley soils may provide the proper amounts for dark tobacco on the best dark tobacco soils.

The most certain way of obtaining good yields and good quality of any of the types of tobacco grown in Kentucky is to build the soil up to a state of productivity that will give good yields—say 1000 pounds or more of leaf an acre in an average season without additional direct fertilization of the crop. Additional fertilization may then be profitable, but primarily thru increased yield rather than by higher quality. It is very difficult, if not impossible, to produce choice quality of the types of tobacco grown in this State on depleted soil thru the use of fertilizers alone.

While it is believed by the writers that heavy, long-time sods are best for both Burley and dark tobacco, in their respective areas, it is also recognized that most tobacco growers do not have land enough to follow this practice. Therefore, experiments herein reported have been made in shorter rotations, in an effort to determine best practices for farmers of limited acreage.

It is the purpose of this bulletin to review the results of experimental work on soil management and fertilizer usage for tobacco already completed, and to make a report on work in progress.

For a number of years it was not possible to properly evaluate the results of some of this work because of lack of proper facilities for curing the tobacco. The quality of the tobacco in several instances was, in the judgment of the writers, considerably lower than it would have been had better curing facilities been available. Until recent years it was impossible to get a reliable rating on the comparative values of the different grades in the various lots of tobacco, consequently only estimates were made. Lately, tobacco has been graded by members of our own staff and Federal graders, according to standard Federal grades. Values are then calculated, using as a basis the average market price for the year for each grade. It is believed, therefore, that relative quality is fairly indicated by the calculated values. It should be stated that the relative values of certain grades of leaf have changed greatly during the years the experiments were in progress.

Where values for tobacco are given, usually the average annual value per hundredweight and average annual acre value are shown. The value per hundredweight is a straight average of the yearly prices, regardless of the yield. Therefore the average yield per acre multiplied by the average price does not give the average acre value. For example, a yield of 500 pounds may sell for $7.00 per hundredweight one year, and 1000 pounds may sell for $14.00 per

hundredweight the next year. The average value per hundredweight is $10.50, and the average acre value $87.50, whereas the average yield of 750 pounds at $10.50 equals $78.75.

In reporting fertilizer experiments the following symbols are used in the tables: O=no treatment; L=ground limestone; M=manure, P=superphosphate, K=sulfate of potash, N=nitrate of soda.

Where every third plot is a check plot, the increases in yield have been calculated upon an assumed uniform variation of soil between check plots. The variation is, of course, not absolutely uniform, but the writers believe that this method is, on the average, the best.

In the six-year rotations reported in this bulletin, bluegrass was the principal grass in the seeding mixture. At all places where this rotation has been used outside the Bluegrass region, good bluegrass sods have been produced where the land was treated with limestone and superphosphate.

REVIEW OF DISCONTINUED WORK PREVIOUSLY REPORTED

Fertilizer tests with Burley tobacco at Lexington. This experiment was begun in 1917 and continued thru 1929. The results were reported in detail in Kentucky Experiment Station Bulletin 331. The experiment was conducted on a block of land that had been used since 1908 for testing tobacco varieties. No fertilizer or manure was used in these tests. The cropping history of the land previous to 1908 is not known. The rotation used in the variety tests was continued. This was a six-year rotation as follows: (1) and (2) tobacco, (3) wheat, (4), (5) and (6) bluegrass. Red clover was seeded with the grass. All crops were removed, including the bluegrass whenever it became large enough to cut. The soil (Maury silt loam, high in phosphorus) is naturally good tobacco land, and it was in good condition when the experiment was begun. The fertilizing materials used were applied to each crop of tobacco at the following rates:

Nitrate of soda	200 lbs. per acre
Sulfate of potash, or its potash equivalent in other salts	100 lbs. per acre
Superphosphate (16 percent)	200 lbs. per acre
Cottonseed meal in amounts to supply nitrogen equivalent to 200 lbs. of nitrate of soda	
Manure	10 tons per acre

Row application of all fertilizers except manure was practiced, except for the second and third years, when half was applied broadcast and half drilled near the row after the tobacco was transplanted.

A root-rot-resistant strain of Burley was used beginning with 1924.

The fertilizer materials were used alone and in various combinations. The most effective treatment was a combination of nitrate of soda and potash. Phosphate added to these materials did not increase the yield. Nitrate of soda alone increased the yield 174 pounds per acre, while potash in addition to the nitrate of soda further increased the yield 65 pounds. Neither the cottonseed meal nor manure treatment increased the yield as much as nitrate of soda.

One set of plots was limed in addition to treatment with nitrate of soda, superphosphate and potash. The rate was 2 tons of ground limestone per acre before the first of the two tobacco crops, after breaking the sod. This was done for two rotations, making a total of 4 tons per acre. The effect of the lime was to reduce the yield of tobacco about 45 pounds per acre, and distinctly lower the quality of the leaf in some years. The average yield of tobacco on the untreated check plots (alternate plots were used for checks) was approximately 1260 pounds per acre. The quality of the tobacco was not noticeably affected by any treatment except limestone. Some conclusions that seem to be warranted by these results are:

When land has been brought to a state of productivity such as used for these tests, the effect of additional fertilizers is chiefly to increase yield, with little or no effect on quality.

Nitrogen in insoluble organic materials, like cottonseed meal, used on a soil as productive as this, is not so effective for Burley tobacco as nitrogen in soluble form, like nitrate of soda. It is believed that the reason for this is that the soil itself furnishes enough nitrogen except in the early stages of growth, when nitrogen in insoluble organic nitrogen fertilizers would not be available in sufficient quantities for a quick early growth for the same reason the soil nitrogen is not.

Manure used on land as productive as this was is valuable only for its plant food content. There is no evidence that it had any value in conserving moisture. As a source of nitrogen, 10 tons was not so effective as 200 pounds of nitrate of soda, for the same reason that cottonseed meal was not. This does not mean that 200 pounds of nitrate of soda is as valuable as 10 tons of manure on soils deficient in nitrogen, but it does mean that the nitrate of soda was more effective in meeting the needs of Burley tobacco in the early stages of

growth on this soil. On land supplying only enough nitrogen to produce 700 to 800 pounds of tobacco, the manure would no doubt have been much more effective than the nitrate of soda. The results emphasize the importance of bringing the land to a high state of productivity before trying to grow tobacco on it.

If limestone is not used judiciously on tobacco land, yields may be reduced or the quality may be impaired or both effects may occur. It will be shown in other experiments reported in this bulletin that limestone may be so used as to produce the desired results with legumes without injury to the tobacco. The best practice is to apply just enough lime following the tobacco crop and just preceding the legume-grass crop to meet the needs of the legumes, thus keeping lime as far away from the tobacco in the rotation as possible. As stated in the introduction, tobacco thrives best on soils of moderate acidity. Lime may be so used as to meet the needs for soil improvement without lowering the acidity to a point unfavorable for tobacco.

Soluble nitrogen materials in water for transplanting tobacco. Requests are frequently received for information on the use of nitrate of soda in the water for transplanting tobacco. Careful tests were made of the practice for two years. In the first year's tests no appreciable injury was done to the plants with as much as 10 pounds of nitrate of soda or 5 pounds of calcium nitrate or 3 pounds of ammonium nitrate in 50 gallons of water, used at the rate of ½ pint per plant. The second year the tests produced decided injury to the plants when a solution of more than 4 pounds of nitrate of soda in 50 gallons of water was used at the rate of ¼ pint per plant, and 4 pounds in 50 gallons produced injury when ½ pint per plant was used. The conclusion was that the use of nitrate of soda or other soluble salt, in water for setting tobacco, in sufficient quantity to have fertilizing value, is inadvisable because of the danger of injury to plants, and that the amount of injury is affected by moisture conditions following transplanting, which are, of course, not predictable. If fertilizers are needed, it is best to properly apply them in the row. (See Bulletin 331 for details of these experiments.)

Fertilizer placement tests with Burley tobacco. In 1930 and 1931 tests were made of various placements of fertilizer for tobacco. A 6-8-6 fertilizer was used (except Test 11), in which the nitrogen was derived from equal parts of nitrate of soda and sulfate of am-

monia—that is, 16.6 pounds of each in each hundred pounds of fertilizer. The fertilizer was used at the rate of 500 pounds per acre. The tests were made on quadruplicate plots. The season of 1930 was very dry at setting time (June 12) and continued so until August, when light rains occurred, following which the tobacco made very rapid growth. There was little injury to the plants.

In 1931 the soil was quite dry when the tobacco was set June 27 with excellent plants, watered liberally. There was a rainfall of 3.56 inches on July 3. The stands on July 16, as the average of each group of four plots, are shown in the last column of the following table. The tobacco made such a poor growth that yields were not obtained. While there is lack of consistency in the results, they indicate that the greater the concentration of fertilizer about the plant, the greater the injury. The placement of the fertilizer, the yields in 1930, and the percentage of stand in 1931 are given below.

	Placement of fertilizer	Lbs. per acre 1930	Percent stand 1931
1	No fertilizer	1395	78
2	In strip 4 inches wide worked into soil 3 to 4 inches	1594	58
3	In strip 8 inches wide worked into soil 3 to 4 inches	1594	46
4	No fertilizer	1313	71
5	In strip 12 inches wide worked into soil 3 to 4 inches	1688	71
6	In bottom of marker furrow, split as with setter shoe, tobacco set in split	1463	29
7	No fertilizer	1313	55
8	In two parallel narrow bands 4 to 5 inches apart and 3 inches deep; tobacco between	1463	36
9	On top of soil, soil ridged over it. Split ridge as with setter shoe. Tobacco set in split	1406	54
10	No fertilizer	1500	66
11	250 pounds per acre of 12-24-12 placed as in No 6	1500	51
12	No fertilizer	1395	62

Rate of fertilizer application in the row for Burley tobacco. In 1930 and 1931 tests were made to determine what amount of fertilizer could be placed in the row for tobacco without injury. The same fertilizer was used as in the placement tests. The ground was marked off for tobacco with a "sled runner" marker which left a furrow about 3 inches deep and 3 inches wide. The fertilizer was spread on the sides and the bottom of the furrow, then the tobacco was set with a tobacco setter, the shoe of which mixed the

fertilizer with the soil to some extent. This method of application is approximately the same as that of the fertilizer attachment on most tobacco transplanters, which drops the fertilizer in the furrow ahead of the shoe. Plots of a single row 25 feet long were used (1/500 of an acre). Following are the rates of application and the average yield of four tests of each rate, in 1930:

Rate of fertilizer per acre	Yield Lbs. per acre
0	1468
400	1500
600	1625
800	1687
1000	1625
1200	1562
1400	1594
1600	1625
1800	1812
2000	1718

There was no consistent relation between the number of plants that survived and the rate of application of fertilizer. However the average survival in the unfertilized rows was slightly greater than where fertilizer was used.

This tobacco was transplanted fairly late (June 12) and had not made a large growth when the drouth of 1930 became severe, consequently it was not so badly damaged as larger tobacco. Rains occurred in late August and this tobacco made a remarkably rapid growth and a much higher yield than early-cut tobacco in the rotation experiments reported on pages 35-41.

Along with this test was a single-series test of a concentrated synthetic fertilizer of the analysis 12-24-12, used at the rate of 200, 300, 400 and 500 pounds per acre. The yields were 1375, 1375, 1500 and 1500 pounds, respectively. There was somewhat less injury than with the other fertilizer. The test was repeated in 1931. The tobacco was set at the same time as in the placement tests of that year, each test being repeated five times. Every rate of application greatly injured the plants this year. The stand was 80 percent on the check plots, 30 percent with the 400-pound rate, and 2.5 percent with the 2000-pound rate. These tests show that the season has much to do with the effect of fertilizer placed in the row, and that it is dangerous to apply much fertilizer in the row unless it is well mixed with the soil. In both years the most favorable placement was mixture with the soil in a strip 12 inches wide. No doubt more favorable results would have been obtained had the fertilizer

been mixed with the soil a week or ten days in advance of setting the tobacco.

EXPERIMENTS IN PROGRESS

Rotation and Soil Treatment Experiments at Lexington With White Burley Tobacco

Yield and quality of White Burley tobacco depend greatly upon the kind of rotation followed in growing the crop. It has long been recognized that next to virgin soil, land that has been in pasture a number of years—particularly bluegrass pasture—produces the finest quality of leaf. In the Central Bluegrass region most growers who have farms large enough to permit, follow a rotation in which land is kept in pasture eight to ten years or longer between tobacco crops. As a rule, two crops of tobacco are grown in succession, and the area is then reseeded to pasture at once. This is a highly desirable rotation for Burley, but it is not practicable on small farms, of which there are many in the Burley district of Kentucky. On these small farms the tillable land must be farmed more intensively, and it is necessary to raise tobacco in rotation with corn, hay, and other crops. At the time the experiments discussed here were started (in 1916) much of the Burley produced on the smaller farms was below average in quality, and in many instances growers were finding it impossible to keep yield at a profitable level. The chief purpose of the experiments was to determine the relative value of certain short rotations and soil treatments for the production of Burley tobacco. The soil on the Experiment Station farm at Lexington, where the experiments were conducted, is classified as Maury silt loam. It is rich in phosphorus and representative of the high-phosphorus soil in the Central Bluegrass region.

The land selected for the experiments had recently been seeded to bluegrass, and a fairly good turf had formed. Previously it had been used for various crops, including tobacco. So far as known, no commercial fertilizers or lime had been used on the land, and manure had not been used for many years, if at all. The soil is fairly well adapted to tobacco and was in a productive condition. However, it is not very uniform in character.

DETAILS OF THE EXPERIMENTS

Experiment No. 1. A four-year rotation of (1) wheat, (2) and (3) orchard grass and clover, and (4) tobacco. Twenty tons of manure an acre were used on the tobacco until 1926, when the application was reduced to 10 tons an acre. It was generally believed that the heavy

turf of old bluegrass pasture was one of the factors responsible for the fine quality of Burley produced in this region, but it is not practical to use bluegrass in a short rotation, as it is slow to become established. Orchard grass makes a heavy turf in two years, and the mixture of clover and orchard grass makes a good hay crop and good pasture. Such a rotation plus the liberal use of stable manure should, it was thought, give soil conditions for tobacco almost as favorable as old bluegrass sod land, and be a practical rotation for the small farm.

Experiment No. 2. The same rotation as in No. 1 was followed, but nitrate of soda at the rate of 200 pounds per acre was used on the tobacco, instead of manure. It was assumed that central Kentucky soils contain sufficient phosphorus and potash for crop needs, and that manure is of benefit chiefly for the nitrogen it furnishes. If so, a nitrogen fertilizer should give as good results as manure. To determine if better quality would be produced by a complete fertilizer, 500 pounds an acre of a 4-8-4 fertilizer was substituted for nitrate of soda in 1928, and used in subsequent years until the experiment was completed. Both nitrate of soda and fertilizers were applied along the rows in all experiments.

Experiment No. 3. The same rotation as in No. 1, but no fertilizers or manure used. This served as a check for comparison with experiments Nos. 1 and 2.

Experiment No. 4. A four-year rotation of (1) wheat, (2) clover, (3) corn, and (4) tobacco. Twenty tons of manure an acre were used on the corn until 1926, when the rate was reduced to 10 tons an acre. At the same time fertilization of the tobacco was begun, the application being 500 pounds of a 4-8-4 analysis per acre. Such a rotation provides for maximum production of grain as well as tobacco and should be especially desirable on small farms where considerable livestock is kept. Corn ground often produces light colored Burley, but small yields. It was believed that by the liberal use of manure on the corn, satisfactory yields and good quality leaf might be obtained. It should be noted that conditions are very favorable for the other crops in the rotation.

Experiment No. 5. A four-year rotation of (1) and (2) alfalfa, (3) corn, and (4) tobacco. Twenty tons of manure an acre were used on the corn, as in experiment No. 4, until 1926, when the rate was reduced to 10 tons an acre, and 500 pounds of a 4-8-4 fertilizer were used on tobacco.

It was necessary to lime the land in order to raise alfalfa. Initial applications of 2 tons an acre were made, and additional applications of 1 ton an acre were made each time alfalfa appeared in the rotation. After two rounds of the rotation no more lime was used, so that the total applications amounted to 4 tons an acre.

It was planned to sow alfalfa after tobacco was harvested, and this was done until late years. Usually, however, the tobacco was harvested so late that the alfalfa winterkilled badly, necessitating resowing in the spring, which was not always successful. It was found more practical to sow wheat after tobacco and to sow the alfalfa in the wheat. Practically as much alfalfa was obtained the first year as where it was sown alone. Many growers who had attempted to raise tobacco after alfalfa reported very poor results. In tests at the Experiment Station, results had been equally unsatisfactory. It was believed that by raising a crop of corn before tobacco any injurious effects that might be due to alfalfa could be avoided.

Experiment No. 6. A three-year rotation of (1) and (2) redtop, and (3) tobacco. Nitrate of soda was used on tobacco at the rate of 200 pounds an acre, since it was believed that only nitrogen was likely to be the limiting element in the soils of central Kentucky. In 1930, because of evidence of potash deficiency, 500 pounds an acre of a 4-8-4 analysis fertilizer was substituted for the nitrate of soda. Redtop sown alone in late fall heaved badly during the winter, and it was necessary to resow in the spring. Weeds also were troublesome, as the grass made a slow growth the first year. Consequently, during the latter years of the experiment wheat was sown after tobacco, and redtop sown in the wheat. The rotation thus became wheat, redtop and tobacco. Redtop was used because it made a turf similar to that of bluegrass. However, it did not make as good a sod in a short time as orchard grass, and the latter was substituted in 1931, but only two crops followed this grass.

Experiment No. 7. A three-year rotation of (1) wheat—rape catch crop which was disked into the soil and a rye cover crop sown, (2) rape seeded again in the spring and plowed under, cowpeas for hay, followed by a rye cover crop, and (3) tobacco. It was recognized when these experiments were begun that soil-borne diseases—particularly black root rot—were probably partly responsible for the low yields of tobacco in short rotations. Little was known about these diseases or methods of control. It was believed that certain crops favored the development of black root rot, and other crops,

of which rape was one, checked development. To determine if this were true was the chief reason for following the rotation in experiment No. 7. With the development of root-rot-resistant tobacco, the rotation was changed to a wheat, red clover, tobacco rotation in 1924. Potash deficiency was apparent at that time, and manure was used on tobacco at the rate of 10 tons an acre for two rounds of the rotation. Afterwards, 500 pounds an acre of 4-8-4 analysis fertilizer was used instead of manure.

Experiment No. 8. A three-year rotation of (1) soybeans for hay, (2) wheat, followed by a catch crop of cowpeas, the peas disked under and a rye cover crop sown, (3) tobacco, followed by a rye cover crop. The chief object in this rotation was to study the effect of soybeans on yield and quality of tobacco. They were becoming a popular crop in the State at that time. In 1924 this rotation was changed to a wheat, soybean, tobacco rotation, using a rye cover crop following soybeans. Potash deficiency appearing, manure was used on tobacco at the rate of 10 tons per acre for two rounds of the rotation, following which 500 pounds an acre of a 4-8-4 analysis fertilizer was used. In 1930 Korean lespedeza was substituted for soybeans. It was cut for hay the second year.

Other experiments. A two-year rotation was included, and tobacco was also grown continuously on the same land for a few years, heavy applications of manure being used on the tobacco. The plots used in these experiments quickly became so badly infested with black root rot that the growth of tobacco was greatly affected; hence the experiments were discontinued and the land used for breeding work by which root-rot-resistant strains of tobacco were developed. By the use of root-rot-resistant strains of Burley, several of which are now available, and the liberal use of manure and fertilizer, good yields of White Burley can be obtained in continuous culture, but probably not very choice quality.

One-twentieth acre plots were used in the experiments. The experiments were in duplicate, and sufficient plots were used so that each crop in the rotation could be grown each year—that is, four plots in each experiment in the four-year rotations and three in the three-year rotations. Therefore, each crop appeared on eight different plots in the four-year rotations, and on six plots in the three-year rotations.

Obviously a rotation experiment—particularly where conducted on soil in productive condition when the experiment is begun—

Table 1. Average yield and value of tobacco in the 4-year rotations at Lexington.

Experiment No.	Crop succession and treatment. (See description of experiments, pages 35-36 for changes in rotations and treatments.)	Yield, pounds per acre				Value, last 7 years of experiment	
		While rotation was being established	2 rounds of rotation		Entire period 1919-35*	Per acre. Dollars	Per 100 lbs. Dollars
			1919-26	1928-35*			
1	Wheat-grass 2 yrs.—tobacco. Manure on the tobacco	1601	1541	1421	1481	241	16.04
2	Same, except fertilizer on tobacco instead of manure	1694	1441	1209	1325	156	11.55
3	Same, without manure or fertilizer	1483	1223	974	1099	110	9.06
4	Wheat-clover-corn-tobacco. Manure on corn, fertilizer on tobacco	1436	1291	1220	1256	160	12.69
5	Alfalfa 2 yrs.-corn-tobacco. Manure on corn, fertilizer on tobacco	1436	1245	1252	1249	158	12.70

* The 1927 crop was destroyed by hail.

Table 2. Average yield and value of tobacco in the 3-year rotations at Lexington.

Experiment No.	Crop succession and treatment. (See description of experiments, pages 37-38 for changes in rotations and treatments.)	Yield, pounds per acre					Value, last 7 years of experiment	
			Two rounds of rotation			Entire period	Per acre.	Per 100 lbs.
		1917	1918-23	1924-29*	1930-35	1918-35*	Dollars	Dollars
6	Grass 2 yrs.-tobacco. Fertiilzer on tobacco	1455	1387	1052	1121	1187	135	12.25
7	Wheat, rape, rye-Cowpeas, rye-tobacco to 1924. Manure or fertilizer on tobacco. Beginning 1924, Wheat-red clover-tobacco.	1440	1320	1332	1254	1302	183	14.54
8	Soybeans-wheat, cowpeas, rye-tobacco to 1924. Manure or fertilizer on tobacco. Beginning 1924, wheat-soybeans, rye-tobacco.	1205	1271	1130	1171	1191	160	13.70

* The crop of 1927 was destroyed by hail.

must be continued for a long period before the effects of the rotation are apparent. For example, in the twenty years these experiments were in progress, tobacco has appeared on the same land but five times in the four-year rotations. Yields were not obtained the first year, and results during the years while the rotations were being established have little or no significance except to show the yielding capacity of the soil and the effects of treatments. In the following table yields for this period are given in a separate column. No attempt was made until the last few years of the experiments to determine the relative value of tobacco grown in the various rotations, for reasons given in the introduction to this bulletin. However, relative quality was noted during the progress of the experiment. The results of these experiments are given in Tables 1 and 2.

DISCUSSION OF RESULTS IN THE FOUR-YEAR ROTATIONS

In all the four-year rotation experiments, except No. 3 where no manure or fertilizers were used, good average yields were obtained during the entire period the tests were in progress. Yields in 1930 were only about half normal because of severe drouth. This accounts chiefly for the lower average yields during the last eight years of the test in experiment No. 1, where treatment or rotation was not changed during the period which tests were conducted. The average yield for this experiment for seven years of the last period (omitting 1930) was 1491 pounds, or only 50 pounds an acre less than for the first period, which shows that manure alone maintained the yield at a relatively high level. The average price of Burley on the Lexington market for the seven years for which values are given was $16.25, and for the Burley district as a whole, $15.99. It is evident, therefore, that the tobacco in experiment No. 1 was just about average quality. Reducing the amount of manure one half did not affect yield or quality.

In experiment No. 2, yield and quality for the first period were only slightly lower than in experiment No. 1. During the last period, however, both yield and quality—especially quality—declined very markedly despite the use of complete fertilizer. Probably the fertilizer did not supply sufficient nitrogen; altho poorer physical condition of the soil may have been partly responsible. It seems evident that rather large amounts of nitrogen must be used if satisfactory results are to be obtained from the use of commercial fertilizer in this rotation; even then it is questionable if as good

quality can be produced as where some manure is used. All crops were harvested in all the rotations. If the grass and clover had been pastured, as would usually be donè in actual farm practice, it is likely that yields and quality would have been better. Small plots cannot well be pastured.

No comment on experiment No. 3 is needed. It is obvious that rotation alone did not maintain yield or quality. Yields in experiments Nos. 4 and 5 tended to increase during the latter years of the test, but quality remained about the same. Since the price was more than $3.00 a hundred below the average price of Burley for the period, the rotations cannot be considered satisfactory from the standpoint of quality. Very high yields of other crops were obtained, however, which partly compensated for the relatively low returns from tobacco. Probably a better quality of tobacco would have been produced if the manure had been used directly on the tobacco crop instead of on corn. Apparently liming in the amounts used in experiment No. 5 did not affect either yield or quality of tobacco adversely, and alfalfa in this short rotation gave as good results as red clover in the wheat-clover-corn-tobacco rotation. The addition of commercial fertilizers was apparently of little benefit. Tobacco following corn varied greatly in yield and quality from year to year. In some seasons the yields were exceptionally good and the quality above average. In other years yields were low, as compared to those in the other experiments, and the leaf of poor quality. It is believed that these marked differences were caused by the prevalence in some seasons of a disease known as brown root rot, which often affects tobacco following corn.

DISCUSSION OF THREE-YEAR ROTATIONS

Various changes in the rotations and treatments were made during the progress of these experiments, which make it difficult to report the experiments. All important changes were made after the previous rotations or treatments had been in use for six years, or two rounds of the rotation. For this reason, yields are given by six-year periods, during which two rounds of the rotations occurred. In addition, for purposes of comparison, yields for 1917, which completed the establishment of the rotations, are also given. The only significant change in No. 6 was made in 1930, when complete fertilizers were substituted for nitrate of soda alone. Five hundred pounds of a 4-8-4 analysis were used per acre. Yields and quality

had been declining, and there were some indications of potash starvation. After the use of complete fertilizers was begun, both yield and quality improved. Late in the experiment, as previously stated, orchard grass was substituted for redtop, but only two crops followed this grass. This experiment may be compared with No. 2 in the four-year rotation. Yields and quality were much the same for the first six to eight years, but yields in No. 6 decreased considerably more in what may be termed the middle period. Tests showed that some black root rot was present, which probably accounts for the lower yield. Later, root-rot-resistant varieties were used entirely. Neither yield nor quality was satisfactory in this experiment, probably because not enough available nitrogen was supplied.

Experiment No. 7 was designed to determine the value of rape in checking development of root rot. Tests showed that all plots of tobacco in the three-year rotation were slightly affected with this disease in 1923—No. 2 as much as any of the others. This is a complicated and impracticable rotation, and in 1923, after two rounds of the rotation, it was decided to change to a wheat and clover-tobacco rotation. At this time, symptoms of potash deficiency appeared, and 10 tons of manure an acre was used on the tobacco. Yield was not improved much, but quality was somewhat better. After using manure for two rounds of the rotation, 500 pounds an acre of a 4-8-4 analysis fertilizer was substituted for the manure. It proved almost as effective as the manure during the last six-year period, probably because of the residual effects of the manure. The wheat-clover-tobacco rotations, together with the use of manure, gave very good yields and nearly average quality of Burley. Sowing grass with the clover is recommended, as the grass prevents loss of nitrogen after clover dies.

Rotation 8 was designed to study the effects of soybeans in the rotation on tobacco. The original rotation was rather complicated, and in 1923 it was changed to a simple wheat-soybean-tobacco rotation. The soybeans were cut for hay and a rye cover crop was used. Manure was applied for two rounds of the rotation, and during the last two rounds 500 pounds an acre of a 4-8-4 analysis fertilizer was used instead of manure. Yield was lower in this rotation than in No. 7, and during the early years, quality poorer. After manure was used, the quality improved, indicating that the poor results which frequently are obtained after soybeans are probably due to lack of nitrogen. Soybeans when taken off the ground add very

little nitrogen to the soil. Grass and red clover or grass and lespedeza are much to be preferred to soybeans in the rotation. Since lespedeza was used in the rotation but a short time, no conclusions regarding its effect on tobacco yield and quality are warranted.

The fertilizer tests with White Burley reported in this bulletin (see Page 30) were conducted on a near-by block of land very similar in character to that used for the rotation experiments, and of about the same initial productivity. The rotation followed was (1) wheat, (2), (3), (4) clover and bluegrass, and (5) and (6) tobacco. In the second year of the rotation, clover predominated, while in the third and fourth years the stand was practically pure bluegrass. As much as possible of the clover and grass was harvested, but it is impossible to cut bluegrass very short, and a dense growth remained after harvesting. In this experiment, as shown in the report, rotation alone maintained a high average yield of tobacco and considerably better than average quality. Fertilizers increased yield somewhat, but did not affect quality to an appreciable extent. It seems evident that this is a better rotation than the best of the rotations in the rotation experiments from the standpoint of quality. Under farm conditions the bluegrass would be pastured, which would add to the effectiveness of the rotation. In this rotation, land is used for tobacco one third of the time, so that to raise 5 acres of tobacco, for example, only 15 acres of land are required. Altho no other crops except pasture and wheat are obtained, it is a very practical method of handling the crop, except possibly on very small farms.

CONCLUSIONS

These experiments demonstrate clearly the great value of manure for tobacco. Only in experiment No. 1, where manure was used directly on tobacco, was the tobacco of average quality. It is possible that almost as good results might be obtained by using very large amounts of complete fertilizer—say enough to furnish 40 to 60 pounds of nitrogen per acre, varying with the productivity of the soil. Certainly much more is necessary than the 500 pounds an acre of the grade used in these experiments.

In experiments Nos. 4 and 5 the total crop yields were so large that it might pay to follow one of these rotations (including wheat), even if the quality of tobacco were below the average. Possibly by using large amounts of fertilizer on tobacco, both yield and quality might be improved.

The development of root-rot-resistant strains of Burley has solved

the problem of maintaining yield where large amounts of manure are available. On the Experiment Station farm, Burley is grown continuously on the same land, which is heavily manured each year. The land is heavily infested with root rot, but the Experiment Station resistant strains yield heavily and the quality is fair. Commercial fertilizers alone have not proved nearly so effective as manure in continuous tobacco culture on the Experiment Station farm, probably because the physical condition of the soil becomes poor. They might be just as effective on some soils, however. Vetch or crimson clover sown with a small grain for a catch crop might take the place of manure. Finally, it is fairly safe to say that most of the very choice Burley will always be obtained where old grass sods are available for the crop.

EXPERIMENTS AT CAMPBELLSVILLE

The Campbellsville soil experiment field was established in 1919. It is located about one mile northwest of Campbellsville, in Taylor County. The soil is derived from the Waverly formation, which is made up of limestone and shale. The soils of a major or a large portion of the following counties are derived from this formation: Allen, Adair, Barren, Bullitt, Casey, Green, Lewis, Monroe, Rowan, and Taylor. The formation is found in smaller areas in Boyle, Clinton, Cumberland, Estill, Garrard, Jefferson, Larue, Lincoln, Madison, Marion, Menifee, Montgomery, Nelson, Powell, Pulaski, Rockcastle, Russell, Wayne, and possibly some other counties.

The soil of the experiment field was in a very unproductive condition when work was begun. An analysis made when the experiment was begun showed the soil to contain approximately the following amounts of nitrogen, phosphorus and potassium in 2,000,000 pounds of soil (the weight of an acre to the depth of about 7 inches):

Total nitrogen	1,960 lbs.
Total phosphorus	1,070 lbs.
Total potassium	13,800 lbs.

The soil is moderately acid (pH 5.5). The productivity of the soil at the beginning of the experiment is indicated by the average acre yield, on the unfertilized check plots, of each of the first three crops in the three-year rotation of tobacco, wheat and clover: tobacco, 418 pounds; wheat, 7.9 bushels; and clover hay, 1,119 pounds.

THE THREE-YEAR ROTATION

The experiment was begun in 1919, and the three-year rotation was continued thru 1928 after which a change to a six-year rotation

was made. However, the tobacco and wheat crops of 1929 belong with the three-year rotation. A mixture of red and alsike clover was used thru 1924. Timothy was added in 1925 (year of harvest), common lespedeza in 1926, alfalfa in 1927, and Korean lespedeza in 1928. Each of these was continued until the rotation was changed as will be noted later.

The limed plots had two applications of 2 tons of ground limestone each between 1919 and 1924.

Manure was used at the rate of 6 tons per acre for the 1926 and 1927 tobacco crops, and 5 tons were used in 1928 and 1929.

Until 1925, superphosphate (16 percent) was used at the rate of 600 pounds per acre for the rotation, applied broadcast on the tobacco ground after breaking.

Sulfate of potash, or its potash equivalent, was used at the rate of 150 pounds per acre for the rotation, for the same time and in the same way.

Nitrate of soda was used at the rate of 100 pounds per acre on the first tobacco crop (1922), and applied along the row after the tobacco was set. In 1923, 1924 and 1925, 200 pounds per acre were used for tobacco, applied broadcast together with the phosphate and potash.

From 1926 to 1928 the fertilizers were used part on tobacco and part on wheat. The following amounts were used on tobacco, applied broadcast:

Superphosphate (16 percent)	350 lbs. per acre
Sulfate of potash	50 lbs. per acre
Nitrate of soda	200 lbs. per acre

For the wheat following tobacco, 250 pounds of superphosphate and 100 pounds of muriate of potash were applied. It probably would have been better to apply all the phosphate and potash for the rotation on the tobacco ground, so that the tobacco crop could have the benefit of it. The yields of wheat and legumes probably would have been very little different from the yields under the method of application used. Thruout the entire period, nitrate of soda was applied as a top-dressing for wheat, at the rate of 100 pounds per acre when spring growth began. Tobacco stalks were returned for the wheat to the plots on which they were grown from 1924 to 1926. The One Sucker type of dark tobacco was grown thru 1926, and White Burley afterwards.

As a change in the rotation was begun with 1928, the results are

Table 3. Crop yields per acre in three-year rotation at Campbellsville.

Plot No.	Treatment*	Tobacco, Lbs. One Sucker Ave. 5 crops		Tobacco, Lbs. Burley 1927-29 Ave. 3 crops		Ave. Value per Cwt.	Wheat, Bus. Ave. 7 crops		Hay, Lbs. Ave. 7 crops	
		Yield	Increase	Yield	Increase		Yield	Increase	Yield	Increase
1	O	454	.....	570	.....	.....**	10.4	.....	1171	.....
2	P	864	394	947	381	$15.10	17.6	7.6	2306	1124
3	PK	866	380	977	416	19.16	18.8	9.1	2311	1117
4	O	502	.....	557	.....	.....	9.3	.....	1205	.....
5	PN	927	432	1063	467	17.29	21.1	11.7	2442	1159
6	PKN	1022	534	1157	523	22.91	21.8	12.4	2785	1425
7	O	481	.....	673	.....	.....	9.5	.....	1438	.....
8	LP	842	368	848	229	11.28	21.1	12.1	3006	1750
9	LPK	905	438	767	203	13.54	20.7	12.3	2931	1857
10	O	460	.....	510	.....	.....	7.9	.....	892	.....
11	LPN	810	331	823	259	12.80	21.9	13.8	2919	1900
12	LPKN	1002	505	1250	631	27.29	21.6	13.3	3333	2187
13	O	516	.....	673	.....	.....	8.5	.....	1273	.....

* See page 30 for symbols and method of calculating increase in yield.

** All check plots rated together=$10.62. The prices are averages for 1927 and 1929 crops. The 1928 crop was unloaded at warehouse and mixed before rating, thru misunderstanding of employees.

presented separately for the two rotations. Tobacco was a failure in 1920. There was no crop in 1921 because dry weather prevented transplanting the crop. Again in 1930 the crop was so badly injured by drouth that the yields are not used. Wheat was a failure in 1920, 1924 and 1928. There was no clover crop in 1924, and cowpeas were grown and turned under. Clover failed in 1926, but the lespedeza in the mixture had reseeded itself and made a good crop that year, and the crop is included in the average hay yields. (See Bulletin 322 for further details.)

The crop yields in the three-year rotation are given in Table 3. The tobacco yields extend thru 1929 (failure 1930), the wheat yields thru 1931, and the hay yields thru 1928, as the changes in the rotation begun in 1929 did not affect the crops until after these dates.

THE SIX-YEAR ROTATION

A change was begun in 1929 to a six-year rotation of wheat, followed by three years of grass and legumes, and two years of tobacco (cover crop between tobacco crops). The grass and legume mixture consisted of bluegrass and a small amount of redtop seeded in the fall with the wheat, and red clover, alsike clover and lespedeza seeded in the spring. The first sod preceding tobacco after the change in rotation was only two years old when plowed for tobacco. The rates per acre and methods of application of the various fertilizing materials for each tobacco crop were as follows:

Superphosphate (20 percent)	250 lbs.
Sulfate of potash	100 lbs.
Nitrate of soda	200 lbs.

Of the above amounts of fertilizers, 125 pounds of superphosphate, 25 pounds of sulfate of potash and 75 pounds of nitrate of soda were applied at the row. This is the equivalent of 300 pounds per acre of a 4-8-4 fertilizer where all three materials are used. The remainder of the superphosphate and sulfate of potash was applied broadcast, and the remainder of the nitrate of soda was used as a side-dressing after the tobacco was about 8 inches high. No additional fertilizers were applied for the other crops of the rotation, except that 100 pounds of nitrate of soda were used as a top-dressing for wheat on plots receiving nitrogen. Manure was used on all plots for each tobacco crop at the rate of 6 tons per acre.

No lime has been applied since the change in rotation because it had been used in excess in the old rotation. There are no indications of the need for additional liming.

Table 4. Crop yields per acre in six-year rotation at Campbellsville.

Plot No.	Treatment*	Burley Tobacco, Lbs. Ave. 6 crops (1931-36)				Wheat, Bus. Average 3 crops**		Average annual yields of hay, lbs.† 1st-year hay Ave. 5 years		2nd-year hay Ave. 3 years	
		Yield	Increase	Average value Per cwt.	Average value Per Acre	Yield	Increase	Yield	Increase	Yield	Increase
1	M	848	.....	$10.61	$ 99	15.3	.....	2092	.....	1187	.....
2	MP	1216	347	17.93	221	20.8	5.0	3212	1128	1987	698
3	MPK	1248	358	19.04	243	21.4	5.2	3076	1000	1973	582
4	M	911	.....	13.79	142	16.7	.....	2068	.....	1493	.....
5	MPN	1347	434	16.86	227	27.6	10.3	3584	1381	2073	449
6	MPKN	1434	519	18.88	270	29 5	11.6	3888	1551	2227	471
7	M	917	.....	11.67	113	18 5	.....	2472	.....	1887	.....
8	MLP	1170	320	14.49	163	27.2	10.3	4528	2187	2933	1364
9	MLPK	1139	355	14.45	150	25.7	10.4	4220	2009	2340	1089
10	M	717	.....	9.08	61	13.7	.....	2080	.....	933	.....
11	MLPN	1333	517	16.29	203	28 2	13.3	4696	2220	3087	1554
12	MLPKN	1413	498	17.61	248	27.2	11.1	5724	2852	3447	1314
13	M	1014	.....	13.51	143	17.3	.....	3268	.....	2733	.....

* Treatment in addition to manure. See Page 30 for symbols and method of calculating increase in yield.

** Wheat appears in alternate years.

† In a six-year rotation like this a field lies in grass three years after wheat; consequently two fields are in grass at the same time in alternate years.

The hay yields are reported as first-year and second-year crops. When two cuttings were made the same year, both were included in the averages. The third-year grass has been harvested in the past, but will be allowed to remain on the ground in the future and be clipped to approximate somewhat the common practice of pasturing grass land that is to be plowed for tobacco. Crop yields for this rotation are given in Table 4.

DISCUSSION OF RESULTS

The three-year rotation. Superphosphate was by far the most effective of the various fertilizer materials used. While limestone increased the yields of wheat and hay, it did not increase the yield of tobacco. The average yield of One Sucker tobacco was slightly less, and of Burley decidedly less, as an average, on the limed plots than on the similarly fertilized but unlimed plots. However, the best yield and highest quality of Burley tobacco in the three-year rotation were on Plot 12, limed and treated liberally with a "complete" fertilizer. Heavy fertilization with a "complete" fertilizer seems under some conditions to overcome the ill effects of too much lime. Since the yields of wheat and hay are higher on the limed land, the conclusion seems warranted that this soil was limed heavily enough to injure tobacco, particularly Burley tobacco. It was limed more heavily in the beginning than was necessary for legumes. Frenching was frequent on the limed plots, but was never observed on the unlimed plots. Lime may be used to improve land for tobacco, but it should be used in the smallest quantity that will produce a good growth of legumes, and the application should be as long before tobacco as possible.

Potash and nitrate of soda both profitably increased the yield and quality of tobacco when all plots treated with them are considered, but were not very effective on wheat and hay, except that nitrate of soda gave a fair increase of wheat on unlimed land. It should be stated that Plots 10 and 11 are on ground that was a little poorer, and Plot 12 on ground that was a little richer than the average when the experiments were begun.

The six-year rotation. The detrimental effect of limestone on the yield of tobacco has about disappeared in the period of the six-year rotation (the last application of limestone was made in 1924), but the quality is not so good on limed land. The average effect of potash on the yield of tobacco is much smaller, while the effect of

nitrate of soda on yield remains about the same as in the three-year rotation. The reduced effectiveness of potash fertilizer in the period of the six-year rotation may be due to the use of manure uniformly on all plots. The potash contained in the manure would supply in large measure the crop needs for this element. However, the effect of potash on the quality of the tobacco has made its use profitable when all plots are taken into consideration. Nitrate of soda does not seem to have improved quality on unlimed soil, but seems to have improved it on limed soil.

Attention is called to the higher yields of tobacco and other crops in the six-year rotation than in the three-year rotation. It is, of course, not possible to determine the relative influence of weather conditions in the two periods, nor is it possible to tell how much the effect of soil improvement of the three-year rotation carried over into the six-year rotation. However, the cumulative effect of good soil management practices is clearly evident. On the fertilized soil in the six-year rotation excellent bluegrass sods have been produced, such as are recognized in the Central Bluegrass region as giving the best soil conditions for producing Burley tobacco of high yield and quality.

The tobacco crop of 1933 followed the first full-term bluegrass sod in this rotation. A very heavy sod had developed on the treated plots. After breaking, the land was manured uniformly at 6 tons per acre on both fertilized and unfertilized plots. Some of the yields and values were as follows:

	Yield	Price rating
Manure, (check plots)	990	$ 4.73
Manure, superphosphate	1512	13.12
Manure, complete fertilizer	1696	12.35
Limestone, manure, complete fertilizer	1800	12.27

The ability to grow high yields of good quality tobacco makes possible the tillage of smaller acreages and the keeping of more land in soil improving and conserving crops, such as good pasture and hay crops. Higher acre yields need not mean overproduction, but usually they do mean cheaper production.

EXPERIMENTS AT GREENVILLE

Fertilizer experiments with dark fired tobacco were begun on the Greenville soil experiment field in 1914. The soil is classified as Tilsit silt loam, and fairly represents the uplands of the Western Coal Field and the sandstone area on its borders. This soil and

those similar to it are low in phosphorus and are moderately acid. This particular soil contains approximately 700 pounds of phosphorus in 2,000,000 pounds of soil and has a reaction of approximately pH 5.5. The potassium content is approximately 25,000 pounds, and the nitrogen content at the beginning of the experiment was approximately 1,800 pounds. The area on which the tobacco experiments are located has somewhat better natural drainage than much of the more level uplands of the Western Coal Field, and was not, therefore, tile drained as was the remainder of the field. (See Bulletin 322.) It is advisable to confine tobacco to the best drained soil of the farm.

THE THREE-YEAR ROTATION

For two years the rotation was tobacco, potatoes, and clover, after which wheat was substituted for potatoes, the first wheat crop appearing in 1917. In 1925 a change was begun to a six-year rotation consisting of wheat, followed by three years of grass and legumes, and two years of tobacco (cover crop between tobacco crops). The report on this experiment will be made in two parts, corresponding to the two rotations. However, the tobacco crops of 1926-27 followed a clover sod of the old rotation and will be included with the first period. Wheat thru 1928 will be included in the first period.

Limestone and the various fertilizer materials were used at the following rates: Limestone was used on the limed plots of the first of the three series of plots necessary for the rotation at the rate of 2 tons per acre in 1913 and again in 1917, while on the other two series it was used at the same rate three times between 1913 and 1919.* Limestone screenings of ¼ inch and finer were used. Too much limestone was used, but it was done before the bad effects of heavy liming for tobacco were realized. Furthermore, it was thought that heavier applications of such screenings were needed than if finer material had been used.

Superphosphate (16 percent) was used at the rate of 600 pounds per acre for the rotation thru 1920. The rate was 300 pounds from 1921 to 1925, and 350 pounds in 1926 and 1927. It was applied broadcast on tobacco ground, except that part of it was used for potatoes the two years they were grown.

One application of 300 pounds of sulfate of potash per acre was used in the beginning, after which 150 pounds, or its equivalent in

*Thru error the total amount of limestone used in this rotation was stated in Bulletin 272 as 4 tons per acre.

other potash salts, was used for the rotation until 1927, inclusive. It was applied broadcast at the same time as the superphosphate.

Nitrate of soda was used at the rate of 100 pounds per acre for tobacco (except 200 pounds on Plot 8—one half at topping time) thru 1922, the application being made around the hill at setting time. From 1923 to 1927 it was used at the rate of 200 pounds per acre, broadcast at the time the other fertilizers were applied.

The applications of fertilizers thru the period of the three-year rotation shown in Table 5 were equivalent to approximately the following average annual applications per acre:

Superphosphate (16 percent)	160 lbs.
Sulfate of potash, or its potash equivalent	70 lbs.
Nitrate of soda on tobacco	145 lbs.
Nitrate of soda on wheat	100 lbs.

Tobacco stalks were returned for the wheat plots thru 1926, except one year when they were used on the tobacco land. Wheat straw was returned to the clover sod from 1921 to 1923.

Changes were made in treatment as follows in 1915 and 1916: Plot 2, originally treated with limestone and potash, was changed by including superphosphate. Plot 4, originally untreated, was changed to superphosphate and nitrogen. Plot 5, originally limestone, potash and nitrogen, was used for a check plot, as these materials had little or no effect on yields in the absence of a phosphate fertilizer. White Burley tobacco was grown on Plot 9 thru 1921, after which dark tobacco was used. Yields for amended treatments up to 1925 will be found in Bulletins 228 and 272. Yields for the original treatments on the amended plots are given in Bulletin 199.

The first wheat crop appeared in this rotation in 1917, but is omitted from the averages because the clover preceding the wheat did not receive the amended treatments. The averages for the other plots are but little affected by omitting this crop. The wheat crop of 1924 was winterkilled, and there was no crop in 1926 because wet weather prevented seeding wheat in 1925. With the change to a six-year rotation, wheat appears in alternate years; consequently there was no wheat in 1927, which is included in the three-year rotation period.

The first clover hay crop in the three-year rotation was in 1914. There was a failure in 1916, but a crop was harvested each year thereafter thru 1925, when the change in rotation was begun. Because of the changes in treatments noted above, yields for the three-

year rotation will be given beginning with 1917 for hay and 1918 for wheat and tobacco. These are given in Table 5.

Table 5. Crop yields per acre in the three-year rotation at Greenville experiment field.

Plot No.	Treatment*	Dark Fired Tobacco, Average 11 crops, 1917-27				Wheat, Bus. Ave. 8 crops		Hay, Lbs. Ave. 9 crops	
		Pounds		Average value					
		Yield	Increase	per Cwt.	per Acre	Yield	Increase	Yield	Increase
1	LP	820	457	$7.39	$67	20.6	13.5	3281	2543
2	LPK	940	577	9.03	91	20.7	13.6	3644	2906
3	LPN	826	463	7.46	64	21.4	14.3	3418	2680
4	PN	840	477	7.22	69	17.3	10.2	2255	1517
5	None	363	.....	4.15	18	7.1	.....	738	.....
6	LPKN	945	582	9.29	90	21.0	13.9	3161	2423
7	PKN	994	631	9.89	104	19.5	12.4	2642	1904
8	LPK2N**	934	571	9.76	96	18.3	11.2	2794	2056
9	LP	Burley tobacco part of time				18.8	11.7	3308	2570

* See Page 30 for symbols used.
** See preceding statement.

THE SIX-YEAR ROTATION

As previously stated, beginning in 1926 a change was made to a six-year rotation of wheat, followed by a legume and grass mixture for three years, and two years of tobacco (cover crop between tobacco crops). For the first two seedings, the mixture was lespedeza, redtop and bluegrass. Since then, red clover and alsike clover have been included in the mixture.

These experiments were among the earliest laid out by the senior author, and the importance of frequent check plots and replications of treatments was not fully appreciated. To overcome, in part, these defects by providing repetition of treatments, most of the plots (originally 1/10 acre) were divided into two 1/20-acre plots, beginning with the tobacco crop of 1928. The first half of each plot, retained the old number and received the original treatment. The second half, designated by "a", was modified as will appear in Table 6.

The rates of fertilizer applications per acre in the six-year rotation, for each tobacco crop were:

Superphosphate (20 percent)	250 lbs.
Sulfate of potash	100 lbs.
Nitrate of soda	200 lbs.

Of these amounts, 80 pounds of superphosphate, 25 pounds of sulfate of potash and 50 pounds of nitrate of soda were applied at the hill when the tobacco was transplanted. Where all three materials were used, they were equivalent to 200 pounds of a 4-8-6 analysis fertilizer. The remainder of the phosphate and potash was applied

Table 6. Crop yields per acre in the six-year rotation, Greenville experiment field.

Plot No.	Treatment*	Dark Fired Tobacco, Ave. 9 crops 1928-36				Wheat, Bus. Average 4 crops		Ave. annual yields of hay, Lbs.			
		Pounds		Average value				1st year hay Average	2d year hay Average	1st year hay Average	2d year hay Average
		Yield	Increase	per Cwt.	per Acre	Yield	Increase	3 Years	3 Years	3 Years	3 Years
1	LP	1018	552	$6.63	$ 70	21.8	17.2	4187	2663	5320	2007
2	LPK	1221	755	7.64	92	19.2	14.6	4193	2843	5380	2140
2a	LPKN	1239	773	8.05	102	24.0	19.4			5520	2133
3	LPN	1036	570	7.20	80	23.9	19.3	4067	2540	5187	2153
3a	LP(2K)N	1171	705	7.58	91	23.0	18.4			5327	2073
4	PN	954	488	6.56	67	20.6	16.0	3430	1547	4133	1647
4a	PKN	1100	634	8.52	100	18.5	13.9			3727	1540
5	None	466	.....	5.25	28	4.6	.....	767	477	1387	600
6	LPKN	1169	703	8.37	100	24.1	19.5	3567	2110	4520	1833
6a	LPK	1080	614	8.50	95	18.5	13.9			5027	1800
7	PKN	1132	666	8.61	103	21.2	16.6	3377	1540	4280	1707
7a	PK	1034	568	8.10	86	14.5	9.9			4113	1527
8	LPKN	1107	641	7.61	86	20.8	16.2	3123	1607	4280	1427
8a	LPK	1006	540	7.79	81	15.8	11.2			4080	1360
9	LP-Stks	1082	616	8.67	97	18.3	13.7	3830	2673	4853	1907
9a	LPM	1528	1062	9.43	144	23.9	19.3			7527	2600
Av. 2, 6a, 8a	LPK	1102	636	7.98	89	17.8	13.2			4830	1767
Av. 2a, 6, 8	LPKN	1172	706	8.01	96	23.0	18.4			4773	1798
Av. 4a, 7	PKN	1116	650	8.51	102	19.9	15.3			4004	1624

* See Page 30 for symbols used.

broadcast, and the remainder of the nitrate of soda was applied as a side-dressing when the tobacco was about 6 to 9 inches high.

Nitrate of soda was used as a spring top-dressing on wheat on the nitrogen plots at the rate of 100 pounds per acre.

On plot 9, in addition to superphosphate, tobacco stalks were applied at the rate of 300 pounds per acre for each tobacco crop. On Plot 9a, in addition to superphosphate, manure was applied at the rate of 10 tons per acre on the first six crops and 6 tons per acre for the last three crops.

The crop yields for the six-year rotation are given in Table 6. Since some of the hay crops appeared in the six-year rotation before the plots were divided, these crops are given in separate columns in the table. When two cuttings of hay were made the same year, both were included in the averages.

The hay is given for the first and second years of its place in the rotation. Sometimes the third-year crop was harvested, but in future it will be kept clipped and left on the ground to approximate pasturing. Pasturing cannot well be done on small plots, and all growth should not be removed, especially where no manure is returned.

DISCUSSION OF RESULTS

The three-year rotation. The outstanding result on this soil is the effect of phosphorus. In 1913, before the fertilizer experiments were started, the plots were planted to cowpeas, without fertilization, and the cowpeas were turned under. The various plots were then fertilized according to plan, except that no nitrate of soda was used, and seeded to rye, which was turned under the next spring, followed by tobacco. Following are some of the yields of tobacco from this crop, which show the great deficiency of phosphrus in this soil:

No treatment	575 lbs.
LK	760 lbs.
LKN	580 lbs.
LPKN (average two plots)	1505 lbs.
PKN	1625 lbs.
LPN	1595 lbs.
LP	1235 lbs.

As stated, too much limestone was used for land on which tobacco was to be grown, and the tobacco was unfavorably affected by it for several years after the repeated applications were made. However, the first crop of tobacco, which was preceded by an application of only 2 tons of coarse screenings per acre, was not favorably

affected by the limestone (see yields above). The yields of wheat and clover were increased by limestone, as will be seen by examining Tables 5 and 6. The tobacco would no doubt have been indirectly benefitted thru the larger growth of legumes produced by the lime if too much had not been used. This soil, while moderately acid, does not require so much lime as was used here to meet the needs of legumes. One to 2 tons per acre would have been sufficient for legumes for several years.

Potash had a favorable effect on both yield and quality of tobacco, but its effect on the other crops in the rotation is of doubtful value. Nitrogen seems to have had very little effect on any of the crops in the three-year rotation.

The six year rotation. As in the three-year rotation, phosphorus is outstanding in its effect on all crops as the first limiting element.

Limestone apparently shows a slightly beneficial effect on tobacco (the last application was made in 1919) when Plot 3 is compared with Plot 4, Plot 6 with Plot 7, and Plot 6a with Plot 7a. (See corresponding plots in the three-year rotation.) It continues to show a beneficial effect on legumes. While it is difficult to tell just when the injurious effect of the heavy applications of limestone on tobacco began to disappear, it was roughly about 1931.

Potash had a pronounced effect on both yield and quality of tobacco. This is shown by a comparison of Plot 1 with Plot 2, Plot 3 with Plots 2a and 3a, and Plot 4 with 4a. The average yield in these comparisons was increased 17 percent by the use of potash fertilizer, and the quality, as judged by the price ratings, was improved approximately 15 percent. Such improvement from potash fertilization is to be expected on land cropped so long without the return of manure or crop residues. Manure used for tobacco would have largely supplied the needs of the crop for potash, as indicated by Plot 9.

Nitrate of soda has increased yields enough to make its use profitable when prices are good, but its effect on quality was negligible.

The outstanding feature in the changed rotation and treatments is the effect of manure and superphosphate on Plot 9a, on which the yield has averaged 1528 pounds per acre for nine crops, compared with 1018 pounds on Plot 1 treated the same except for manure. While the rate was heavy (10 tons for each crop from 1928 to 1933, 6 tons since) the benefit was so great that the same poundage of tobacco could have been produced on 80 percent of the land required

with the next best treatment (Plot 2a). In 1934 the yield on Plot 9a (LPM) was 1964 pounds, as compared to the next highest yield (Plot 7, PKN) of 1770 pounds. The average yields of tobacco in the six-year rotation were much higher than they were in the three-year rotation. While the relative effect of weather conditions in the two periods cannot be accurately determined, there seems little doubt that the six-year rotation is more favorable for tobacco than the three-year rotation.

During four years of the six-year rotation a continuous vegetative cover of sod or small grain protects the land against erosion and leaching losses more effectively than the cover in the three-year rotation. There is possibly considerable leaching from a sod of red clover during the winter following harvest, for much of it may die, leaving the land without a green cover to utilize soluble nitrogen.

EXPERIMENTS AT MAYFIELD

Fertilizer and rotation experiments with dark fired tobacco were begun at Mayfield in 1913. The soil is typical of a large part of the area west of the Tennessee river. It is a yellow silt loam, and altho it has not been classified by the United States Bureau of Soils, it is almost certainly Grenada silt loam. An analysis at the beginning of the experiment showed it to contain approximately 1000 pounds of phosphorus, 29,000 pounds of potassium ,and 2000 pounds of nitrogen in 2,000,000 pounds of soil. It is strongly acid (approximately pH 4.9).

Three-year rotations were used until 1929, when a change was begun to a six-year rotation consisting of wheat, followed by three years of grass and legumes, and two years of tobacco (cover crop between tobacco crops). The results will be given in two parts—one for the three-year rotations and the other for the six-year rotation.

THE THREE-YEAR ROTATIONS

Rotation No. 1, including six different treatments (Plots 1 to 6) was wheat, clover and tobacco. Lespedeza and alfalfa were added to the clover from 1926 to 1928. Winter oats was used on Plot 6 thru 1916.

Rotation No. 2 (Plot 7) was winter grain, a mixture of orchard grass and common lespedeza, and tobacco.

Rotation No. 3 (Plot 8) was winter grain, sweet clover, and tobacco.

Rotation No. 4 (Plot 9) was winter grain, common lespedeza and tobacco.

In Rotations 2, 3 and 4 a winter grain cover crop was used until 1921, and was clipped in the spring to prevent its maturing. After that, wheat for grain was used.

As some irregularities arose in establishing the rotations, the yields will be given for the period of 1918 to 1928 (wheat thru 1929). During this period one tobacco crop failed because of dry weather, and one crop was destroyed when the curing barn burned. Wheat could not be seeded for 1920 and 1926 because of wet weather. There was no clover crop in 1919, due to dropping the first series of plots and establishing three series on the area formerly occupied by two, by shortening the plots. (See Bulletin 322 for yields thru 1930).

The limed plots in the experiment were given three applications of ground limestone, 2 tons each, between 1913 and 1919. This was too much, but the effects on tobacco of heavy applications of lime were not known to us at that time. Coarse limestone screenings (¼ inch to dust) were used, and it was thought heavy applications were needed.

Superphosphate (16 percent) was used at an average annual rate of 170 pounds per acre, and sulfate of potash, or its potash equivalent, at an average annual rate of 70 pounds. These were generally applied in sufficient quantities on the tobacco ground for the other crops in the rotation. The applications were heavier in the beginning of the experiments. Nitrate of soda was used on the nitrogen plots, for tobacco, at the rate of 100 pounds per acre for three of the crops in this period, and at the rate of 200 pounds for six crops. It was also used on wheat at 100 pounds per acre as a spring

Table 7. Crop yields per acre in the three-year rotations, Mayfield experiment field.

Rotation No.	Plot No.	Treatment*	Dark Fired Tobacco, Lbs.** Ave. 9 crops		Wheat, Bus. Ave. 10 crops		Wheat, Bus. Ave. 8 crops		Hay, Lbs. Ave. 9 crops	
			Yield	Increase	Yield	Increase	Yield	Increase	Yield	Increase
	1	P	902	278	12.2	7.0	11.1	6.6	1656	586
	2	LP	898	274	21.9	16.7	21.3	16.8	3635	2565
	3	None	624	.....	5.2	.....	4.5	.....	1070	.....
1	4	LPK	932	308	18.0	12.8	17.5	13.0	3801	2731
	5	LPKN	1149	525	23.1	17.9	22.2	17.7	4303	3233
	6	LPN	1120	496	21.4	16.2	22.2	17.7	4234	3164
2	7	P	926	302	.....	.....	13.9	9.4	1967	897
3	8	LP	974	350	.....	.....	21.2	16.7	4460	3390
4	9	P	1010	386	.....	.....	14.0	9.5	2038	968

* See Page 30 for symbols.

** Price ratings were obtained on only the first three of the nine crops. There was no significant difference in the ratings for the different plots. The highest was $13.67 for Plot 6, and the lowest $12.70 for Plot 7.

top-dressing on the nitrogen plots. The fertilizers were applied broadcast, except that nitrate of soda was used two years as a side dressing for the tobacco, soon after setting.

The chief purpose of these tests was to determine the effect on tobacco of increasing the productivity of the soil. For this reason, sufficient phosphate and potash fertilizers for the rotation were applied on the tobacco ground so as to get their full effect on the tobacco and the legumes following. The yields of crops in the three-year rotations are given in Table 7.

THE SIX-YEAR ROTATION

As previously stated, a change was begun in 1929 to a six-year rotation of wheat, followed by three years of grass and legumes, and two years of tobacco (cover crop between tobacco crops). The mixture consisted of bluegrass and a small amount of redtop seeded in the fall with wheat, and red clover, alsike clover and lespedeza seeded in the spring. The new rotation occupies the same plots as the three-year rotations, and therefore replaces all four rotations. It is recognized that the previous rotations introduced some variations in the productivity of the soil. However, it is believed that the yield data have value in showing the importance of building up soil productivity for producing high yields and quality of tobacco. Fertilizer materials were used on each tobacco crop at the following rates per acre:

Superphosphate (20 percent)	250 lbs.
Sulfate of potash	100 lbs.
Nitrate of soda	200 lbs.

Of these amounts, 80 pounds of the superphosphate, 25 pounds of the sulfate of potash, and 50 pounds of nitrate of soda were applied at the hill when the tobacco was transplanted. Where all three materials were used, they were equivalent to 200 pounds of a 4-8-6 analysis. The remainder of the phosphate and potash was applied broadcast, and the remainder of the nitrate of soda was applied as a side-dressing when the tobacco was about 6 to 9 inches high.

No other fertilizers were used in the rotation except that 100 pounds of nitrate of soda per acre was used as a top dressing for wheat on plots receiving nitrogen. Manure was used on all plots for each tobacco crop at the rate of 6 tons per acre (5 tons in 1929).

No lime was applied in this rotation because of previous heavy liming. There is no indication of the need of additional liming.

The yields of crops in the six-year rotation are given in Table 8.

Table 8. Crop yields per acre in the six-year rotation, Mayfield experiment field.

Plot No.	Treatment*	Dark Fired Tobacco, Average 7 crops				Wheat, Bus. Average 3 crops		Average annual yields of hay, Lbs. 1st-Year hay Ave. 5 Years		2d-Year hay Ave. 4 Years	
		Pounds per acre		Average value							
		Yield	Increase	per Cwt.	per Acre	Yield	Increase	Yield	Increase	Yield	Increase
1	MP	1271	162	$7.03	$ 93	19.4	4.1	2074	690	2884	492
2	MLP	1339	230	7.22	97	27.0	11.7	3456	2072	3596	1204
3	M	1109	.....	7.63	87	15.3	.....	1384	.....	2392	.....
4	MLPK	1273	164	7.37	95	25.7	10.4	4259	2875	3996	1604
5	MLPKN	1460	351	7.36	109	32.1	16.8	4198	2814	3608	1216
6	MLPN	1297	188	6.68	89	32.5	17.2	3830	2446	3196	804
7	MPKN	1415	306	7.01	100	26.2	10.0	2285**	901	3084**	692
8	MLP	1262	153	6.76	87	25.2	9.9	4194	2810	4020	1628
9	MP	1313	204	6.60	88	20.1	4.8	1830	446	2904	512

*See Page 30 for symbols.

**Because of the changes in the rotations and the addition of potash to the treatment on tobacco of Plot 7 in the changed rotation (see Plot 7, Table 7), the first-year hay was not affected by potash on Plot 7 until 1932 and the second-year hay until 1933.

The tobacco crop of 1933 was drowned out by torrential rains the latter part of July. While the tobacco crops of 1929 and 1930 followed the one-year sods of the three-year rotations, they are included in the six-year rotation because both crops were grown on the same series of plots as in the six-year rotation and were manured, whereas no manure was used in the three-year rotations. Hay yields are reported as first-year and second-year crops. When two cuttings were made in the same year, both are included in the averages.

DISCUSSION OF RESULTS

There are not enough check plots in these tests for as accurate determination of the effect of treatments as desirable. The importance of frequent checks was not fully realized when these experiments were laid out (1913).

The most important fact determined by these tests is the necessity for using lime and phosphate to promote the growth of legumes to increase productivity. However, the danger of overliming is clearly indicated by a comparison of Plot 1 with Plot 2, which shows a much increased yield of wheat and hay for liming thruout the three-year rotation, but shows a decrease for tobacco for the second half of this rotation period. The yields of tobacco on Plot 1 (P) and 2 (LP) for the first seven crops in the three-year rotations were 748 pounds and 1005 pounds, respectively; whereas for the next seven crops the yields were 953 pounds and 865 pounds, respectively.* The last applications of limestone were made in 1918 and 1919. The yields of the first seven crops of wheat averaged 15.3 bushels and 23.4 bushels, respectively, for the two treatments, while for the next seven crops the average yields were 10.8 bushels and 20.8 bushels, the percentage of increase being greater in the second period than in the first. The average yields of hay for the first six crops were 1985 pounds and 4292 pounds, respectively, and for the next seven crops 1328 pounds and 3024 pounds, the percentage of increase for lime being greater in the second period than the first. The same trend is seen in comparing wheat and tobacco on Plot 8 with Plot 7. Hay cannot be compared because different hay plants were used. Potash and nitrate of soda in addition to phosphate on limed ground seem to have overcome the depressing effect of lime during the period of the three-year rotation. It will be observed (Table 8) that for the seven crops in the six-year rotation

* See Ky. Exp. Sta. Bul. 322.

the depressing effect of lime on tobacco has disappeared and some increase has been produced on Plot 2 as compared with Plot 1, and Plot 8 as compared with Plot 9.

Potash had a beneficial effect on tobacco, which was greater in the three-year rotation after the land was so heavily limed (see Bulletin 322). The same was largely true of nitrate of soda. The increase in the yields of tobacco from the use of potash and nitrate of soda declined in the six-year rotation. The decline was due, perhaps, in part to the greater time since liming, and in part to the uniform use of manure on all the plots; the manure of course supplied considerable potash and nitrogen.

Top-dressing wheat with nitrate of soda in the spring was quite effective in increasing wheat yields, particularly in the six-year rotation. Potash had little effect on wheat, but was fairly effective on hay in the six-year rotation. The use of potash seems advisable for tobacco on this soil, and its residual effect on hay yields further increases its profitableness.

The yields of tobacco were much better in the six-year rotation than for a similar period in the last part of the three-year rotation. It is, of course, not possible to estimate to what extent the differences were caused by differences in weather conditions, but it is believed that the six-year rotation and the use of manure are much more favorable for tobacco than the three-year rotations, for it will be observed that the treatment of manure alone in the six-year rotation produced almost as great an average yield of tobacco as the best fertilizer treatment in the three-year rotation, and that it produced the highest qualtiy as measured by the price rating.

EXPERIMENTS AT THE WESTERN KENTUCKY SUBSTATION

The tobacco experimental plots are located on soil of limestone origin. It has not been classified by the United States Bureau of Soils, but it is almost certainly Decatur silt loam. It contains about 940 pounds of phosphorus and 33,600 pounds of potassium in 2,000,000 pounds of surface soil, and when the work was begun approximately 2000 pounds of nitrogen. The soil is moderately acid (pH 5.5). Two different experiments are conducted with dark fire-cured tobacco—one being fertilizer tests, and the other rotation tests.

THE FERTILIZER TESTS

These experiments are made in a six-year rotation of wheat, legume and grass mixture for three years, and two years of dark fired tobacco (cover crop between tobacco crops). Three series of plots

are required for this rotation, for wheat comes in alternate years, and the grass and legume mixture occupy the land three years. The fertilizer tests on tobacco were begun with the 1927 crop, wheat being seeded in the fall of 1926 and the legume and grass mixture the following spring on the other two series of plots. In the first round of the rotation the grass mixture was red clover, alsike clover, lespedeza, orchard grass and redtop. After that, bluegrass was substituted for orchard grass. Korean lespedeza was used from the beginning. Some common lespedeza was included at first, but was later omitted. In establishing the cropping system, the tobacco crops of 1927 and 1928 did not follow grass sods, but were on land that was cropped to corn in 1926.

Limestone, where used, was applied at the rate of 2 tons per acre in the beginning of the experiment. None has been used since.

The standard rates of fertilizer applications per acre for each tobacco crop were as follows:

Superphosphate (20 percent)	250 lbs. (280 lbs. 1927 and 1928)
Sulfate of potash	100 lbs. (50 lbs. muriate 1927 and 1928)
Nitrate of soda	100 lbs.

On certain plots, double the standard application was used, as indicated in Table 9. Of these amounts, 80 pounds of the superphosphate, 25 pounds of sulfate of potash, and 50 pounds of nitrate of soda were applied at the hill when the tobacco was transplanted. Where all three materials were used, they were equivalent to 200 pounds of fertilizer analyzing 4-8-6. The remainder of the phosphate and potash was applied broadcast, and the remainder of the nitrate of soda was used as a side-dressing when the plants were about 6 to 9 inches high. On Plot 8, where double the standard application of nitrate of soda was used, 150 pounds were used as the side-dressing, at the regular time, while on Plot 9, 75 pounds were applied as a side-dressing at the regular time and 75 pounds shortly before topping time. For the crops of 1927 and 1928, 300 pounds were used on Plot 9.

On Plot 18, 10 tons of manure per acre were used on each tobacco crop from 1927 to 1932—that is, for one round of the rotation. Beginning with the second round, 6 tons were used.

No additional fertilizer was used for wheat or hay, except that nitrate of soda was used as a spring top-dressing on wheat at the same rates as for tobacco. However, in starting the rotation in 1926, fertilizers were applied for wheat and grass which preceded the tobacco crop.

Table 9. Crop yields per acre in the fertilizer tests on tobacco at Princeton Substation.

Plot No	Treatment*	Dark Fired Tobacco, Lbs.								Wheat, Bus.		Ave. annual yields of hay, Lbs.			
		Average first 2 crops				Ave. 8 crops 1929-36				Average 4 crops		1st-year hay Ave. 5 years		2d-year hay Ave. 3 years	
				Ave. annual value**				Average value							
		Yield	Increase	Per cwt.	Per acre	Yield	Increase	Per cwt.	Per acre	Yield	Increase	Yield	Increase	Yield	Increase
1	None	867	.....	$18.55	$157	910	.....	$ 9.98	$ 94	10.9	.....	1272	.....	2247	.....
2	P	985	161	12.82	127	986	82	8.90	90	11.3	0.5	1326	41	1893	—229
3	PK	919	138	16.64	100	1069	172	8.90	97	10.5	—0.2	1464	165	1980	— 18
4	None	738	.....	16.04	117	891	.....	9.17	83	10.6	.....	1312	.....	1873	.....
5	PN	1170	465	13.33	159	1138	263	10.40	122	19.1	9.2	1670	472	2167	393
6	PKN	1127	454	18.36	204	1187	327	9.78	122	18.9	9.7	1640	556	2133	457
7	None	640	.....	13.78	87	844	.....	8.88	78	8.5	.....	970	.....	1577	.....
7a	None	.....	.....	.....	.....	874	.....	8.83	79	9.3	.....	1138	.....	1683	.....
8	PK2N	1121	447	12.05	139	1253	354	9.08	117	21.4	11.8	1606	417	2173	429
9	PK2N	1152	445	17.15	197	1205	281	9.44	121	21.6	11.6	1518	279	2073	267
10	None	741	.....	12.12	91	949	.....	9.33	91	10.3	.....	1290	.....	1867	.....
11	2(PKN)	1234	532	16.90	208	1282	347	9.81	133	23.6	13.2	2174	959	2463	579
12	LP	846	183	13.43	115	1120	200	11.05	131	17.2	6.8	3004	1863	2860	960
13	None	624	.....	12.30	81	906	.....	9.30	86	10.5	.....	1066	.....	1917	.....
13a	None	.....	.....	.....	.....	891	.....	9.48	85	10.8	.....	1268	.....	1937	.....
14	LPK	815	190	10.26	86	1152	270	10.92	133	16.0	5.5	3168	1941	2640	758
15	LPN	904	277	13.90	126	1177	304	10.88	135	21.0	10.9	3120	1935	2707	879
16	None	628	.....	16.24	102	864	.....	9.91	89	9.8	.....	1144	.....	1773	.....
17	LPKN	1017	403	11.13	116	1216	343	11.32	143	21.0	11.2	3292	2149	2507	681
18	LPM	1230	631	14.50	183	1285	402	11.97	160	21.9	12.0	4150	3009	3323	1443
19	None	585	.....	13.61	80	892	.....	9.80	91	9.9	.....	1140	.....	1933	.....

* See Page 30 for symbols and method of calculating increase in yield.

** The price ratings and acre values on these two crops are not regarded as having much significance. The ratings and values on the other crops were made upon a better basis (see Page 29).

The results of these tests are given in Table 9. Since the first two tobacco crops (1927 and 1928) did not follow a grass and legume sod, the yields are given in a separate column. When more than one cutting of hay was made in a year, the yields are included in the averages.

THE ROTATION TESTS

In comparison with the six-year rotation used for the tobacco fertilizer tests, four four-year rotations and one eight-year rotation were tried. All land for these rotations was limed at the rate of 2 tons per acre in the beginning of the experiment, and the tobacco was fertilized with superphosphate and sulfate of potash used at same rate as in the fertilizer tests. Enough additional fertilizer was supplied to the wheat to give the same average annual rate for the rotation as in the six-year rotation of the fertilizer tests. The rotation tests were made in duplicate.

Since tobacco did not appear after a sod in some of the rotations until the fourth year of the tests, the average yields of tobacco are given for only the last seven years. The yield of tobacco on Plot 14 in the six-year rotation is used to represent that rotation because it had the same fertilizer and lime treatment as the other rotations.

No manure or nitrogen fertilizer was used in the rotation tests, in order not to obscure the full effect of the rotations on the yield and quality of tobacco.

When the tobacco rotations were started, two or three plots in the

Table 10. Average acre yield and value of dark fired tobacco in various rotations.

Rotation No.	Rotation	Tobacco 1930–36 Pounds	Annual value Per cwt.	Annual value Per acre
	Four-year rotations			
1	Wheat, alfalfa, alfalfa, tobacco	1113	$8.99	$105
2	Wheat, clover, orchard grass, tobacco	1126	9.20	109
3	Corn, wheat, clover, tobacco	1026	8.04	86
4	Wheat, clover, corn, tobacco	965	7.59	76
	Eight–Year Rotation			
5	Wheat, clover and bluegrass 5 years, tobacco, tobacco	1138	9.62	113
	Six-Yr. Rotation of Fertilizer Tests, Plot 14			
6	Wheat, clover, lespedeza and grass 3 years, tobacco, tobacco	1105	9.42	107

set of plots required for each rotation were seeded to wheat and harvested in 1927. The average yield for each of the rotations was as follows:

Rotation No.	Bushels per acre
1	11.2
2	10.4
3	11.3
4	11.8
5	12.5
6	10.7

These yields indicate that there was no serious variation in the productivity of the soil in the plots from which wheat was harvested in 1927, assuming that the yield of wheat is a fair measure of productivity.

DISCUSSION OF RESULTS

On the unlimed ground in the six-year rotation neither superphosphate nor the combination of superphosphate and potash has been very effective in increasing the yields of any of the crops. A combination of superphosphate, potash and nitrate of soda gave the largest increase in tobacco, but did not increase the yield of wheat or hay very much over the superphosphate and nitrate of soda treatment. Doubling the application of nitrate of soda (Plot 8) increased the yield of tobacco only slightly, and of wheat about 2 bushels per acre. Doubling the standard application of all the fertilizers did not appreciably further affect the yield of tobacco, but increased the average acre value of tobacco $16.00 (compare Plots 8 and 11). Limestone and superphosphate profitably increased the yields of all the crops. Potash in addition to limestone and superphosphate (Plot 14) was not profitable. Nitrate of soda in addition to limestone and superphosphate was of doubtful value for tobacco. The addition of both potash and nitrate of soda to phosphate on limed soil (Plot 17) produced a profitable increase in yield and quality of tobacco. The most effective treatment was limestone, superphosphate and manure (Plot 18). For this treatment the yields of tobacco and hay were considerably greater, and wheat slightly greater, than where limestone and complete fertilizer were used. The yield of hay was considerably above that of any other treatment.

These results warrant the conclusion that the best treatment for this soil for producing tobacco is to use limestone at a moderate rate of not more than 2 tons per acre as an initial application and

superphosphate applied liberally in producing a good grass and legume sod. Manure applied at the rate of 6 to 8 tons per acre supplemented by 300 pounds per acre of a fertilizer of approximately a 4-10-6 analysis should further increase yield and quality. (See Page 70 for directions for applying fertilizer.) If as much as 10 tons of manure per acre can be used, superphosphate would be sufficient fertilizer for tobacco. The results do not warrant the use of potash for any crop except tobacco.

The rotation experiments show the effectiveness of a good grass and legume sod for tobacco, and its superiority over clover alone in these rotations.

Corn grown between the clover and tobacco reduced yield and value of the tobacco crop as compared with tobacco coming first. There was a difference of only 2.6 bushels in corn yield for corn following clover, while there was a difference of 5.8 bushels of wheat in favor of Rotation No. 4. The clover yield was 579 pounds greater in the rotation where wheat followed tobacco than where it followed corn.

RECOMMENDATIONS

1. *Choice and management of soil for tobacco.* Slight differences in the character of the soil, such as occur on practically all farms, may cause a marked difference in the quality of tobacco produced. The grower should be certain, therefore, that he has selected the best adapted land for his crop even if it necessitates some rearrangement of fields or more or less "patch" farming. It seems certain that soil adaptation is determined quite largely by the character of the drainage—at least all good tobacco lands are well drained. Good underdrainage is indicated by well-granulated, reddish, brownish-red or bright yellow subsoil. A light-colored compact subsoil and the presence of dark-colored concretions ("buckshot") are further indications of poor underdrainage.

Soil for tobacco should be sufficiently productive to yield at least 1000 pounds of leaf an acre under average seasonal conditions, without direct fertilization of the crop. High yields can usually be produced, even on thin land, by the use of large amounts of commercial fertilizer, but good quality tobacco of the types grown in Kentucky is seldom produced unless the soil is in a productive condition when utilized for the crop.

The surest way of obtaining a large percentage of the high-priced grades of White Burley tobacco is to grow it on land that has been

kept in pasture for a number of years—the longer the better. Land well supplied with the mineral requirements for crops found chiefly in the Central Bluegrass region of Kentucky is usually in good condition for Burley after several years in pasture, provided legumes are grown in connection with the grass and the pasture is not grazed too closely. If soil is badly depleted, it may be necessary to plow under a crop of legumes or to manure the land before seeding to pasture in order to get a vigorous growth of grasses and pasture legumes.

If soils are deficient in any of the mineral elements of plant food, they should be supplied before seeding the pasture crops. These deficiencies are usually lime and phosphate. County agents are prepared, as a rule, to make soil tests which indicate whether or not lime and phosphate are needed. The amount of lime applied on land to be used for tobacco should not exceed 1 to 2 tons an acre. It should be applied as far in advance of the time when tobacco is to be grown as possible, preferably three or four years. In rotations where tobacco is followed by a small grain, it is a good plan to apply the lime before preparing the tobacco stubble for seeding. It should be thoroly worked into the soil with a disk harrow or other implement. Land for tobacco should be relimed only when there is need for it for legumes in the rotation. This is also the proper place in the rotation to apply the phosphate needed for obtaining a good growth of grasses and legumes. It is recommended that application of 300 to 400 pounds an acre of 20-percent superphosphate, or its equivalent of other phosphates, be used when a soil is deficient in phosphorus.

2. *Grasses and legumes for tobacco rotations.* Where it is desired that land remain in grass three years or more, bluegrass is the ideal grass to sow. For shorter periods, orchard grass is the best grass available. In parts of the dark tobacco districts, redtop is probably preferable to orchard grass. Timothy should not be used in tobacco rotations. (For rates and methods of seeding, see Kentucky Extension Circular No. 242.) Red clover and lespedeza seem to be the best legumes to use with the grass. If bluegrass is to stand for a long period, it is desirable to sow a pound of white clover in addition to the grass and other legume seed.

It is very desirable that the grass-legume mixture be pastured. If used for hay, 8 to 10 tons of manure should be applied when the land is broken for tobacco.

Two crops of tobacco may be grown in succession on land that has been in sod for three or four years. A rye or other cover crop should be grown between tobacco crops. It should not be allowed to become more than 10 or 12 inches high before plowing under.

The same system of soil management recommended for White Burley is as satisfactory for the dark types of tobacco. However, the latter are not quite so exacting in their soil requirements as Burley, and good-quality leaf may be produced by other cropping systems if they provide for the maintenance or restoration of a high state of productivity.

3. *Fertilizing the tobacco crop.* Where soil has been prepared for tobacco as suggested, very heavy fertilization of the tobacco crop is not necessary. Where Burley is grown on good sod land capable of producing 1000 pounds of leaf an acre without additional fertilization, about 300 to 400 pounds of a fertilizer analyzing 4 to 5 percent nitrogen, 8 to 12 percent phosphoric acid, and 6 to 8 percent potash, will usually prove profitable. Those with the higher percentage of phosphate are probably best in areas where soils are deficient in that element. If necessary to raise Burley on less productive soils, from 500 to 800 pounds of fertilizer an acre may be used profitably. The fertilizers should be applied at the row.

In most instances 8 to 10 tons of manure per acre, supplemented by about 200 pounds of superphosphate on low-phosphate soil, will give better quality tobacco than complete fertilizer. The superphosphate should be applied at the row.

For dark tobacco 200 to 300 pounds an acre of a 3-8-6, or similar analysis, is recommended for use at the hills. This should be sufficient on soils already in a productive condition. On less productive soil this may be supplemented by a broadcast application of 200 pounds of superphosphate and 50 to 75 pounds of muriate or sulfate of potash an acre. Fifty pounds of muriate of potash an acre can be used on either Burley or dark tobacco without danger of injuring the quality of the leaf, and probably 75 pounds. Any amount used above this should be in the form of potassium sulfate.

When either Burley or dark tobacco fertilized as recommended fails to make satisfactory growth in favorable weather, lack of nitrogen may be the cause. In such instances growth may be stimulated by side-dressing the tobacco with 100 to 150 pounds of nitrate of soda or sulfate of ammonia per acre. Such applications should not be made too late in the season, however, especially for Burley. The

best time is when the plants are 8 to 10 inches high. Care should be taken not to get any of the fertilizer on the plants.

4. *Placement of fertilizers.* One of the most difficult problems connected with fertilization of tobacco is to get proper placement of the fertilizers. This is particularly true with machine setting of Burley. The best placement for Burley tobacco is in continuous narrow bands on both sides of the row and about 3 to 4 inches from the plants. The depth of placement should be 3 to 4 inches. Some of the setters sold recently have fertilizer distributors which make such placement, but the older ones do not. Most growers have single row fertilizer distributors, and fairly good placement can be made with them if proper care is exercised. The best method is to mark out the land and to run the drill on both sides of the row, leaving a space of 6 to 8 inches between the bands of fertilizer. The tobacco should be set between the bands. Another method is to drill the fertilizer directly in the row a week or ten days before setting the tobacco. It should be mixed with the soil by following the drill with a double-shovel plow or Rastus cultivator with narrow shovels. On the Experiment Station farm, fertilizers have been applied successfully by using two-horse corn planters with fertilizer attachments. The land is marked out and the fertilizer drilled on both sides of the row. Potato planters with fertilizer attachments make a very satisfactory placement, but they do not drill small amounts of fertilizer very evenly.

The method commonly followed in the dark tobacco districts of mixing the fertilizers with the soil in making hills is quite satisfactory for small amounts of fertilizer. The fertilizer should be thoroly mixed with the soil. Where larger amounts are used, it is suggested that most of it be applied in continuous bands on both sides of the row, as recommended for Burley. A hundred pounds an acre may be applied in the hills in addition when the practice of making hills is followed. It is highly important to so place fertilizer that the roots of the plants will not come in contact with it or many of the plants may be killed. The danger of injury is greatest in dry seasons.

It is strongly recommended that, on land subject to washing, tobacco rows be run across the slopes. If the slope is steep, it is advisable to leave sod strips 10 to 15 feet wide at intervals to check the flow of water and reduce erosion.

Kentucky Agricultural Experiment Station

University of Kentucky

REGIONAL DEVELOPMENT OF HOG PRODUCTION IN KENTUCKY

BULLETIN NO. 380

Lexington, Ky.
July, 1938

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Bulletin No. 380

REGIONAL DEVELOPMENT OF HOG PRODUCTION IN KENTUCKY

C. D. PHILLIPS[1]

The production of hogs in Kentucky can be classed as a major farm enterprise in only a few counties of the State, while in the remainder of the State it takes the form of a side line or minor farm project. Even with this variation in production the hog enterprise on Kentucky farms accounted for an average of 8.5 percent of the total cash income of farmers during the past 12 years. This is illustrated in Figure 1. Furthermore, during the same period, the income from hogs amounted to 19 percent of the total cash income received from livestock and livestock products. This also is illustrated in Figure 1. The cash income from hogs does not show the full importance of the enterprise within the State, however, in view of the fact that such a large proportion of the hogs are consumed on farms. During the 10-year period, 1926 to 1935, inclusive, the gross income from hogs in Kentucky averaged $20,954,000, while the average cash income, for the same period, was only $11,038,000.[2] From these figures it can be seen that cash income amounted to only 52.6 percent of the total income received from hogs. The remaining 47.4 percent was the value of the hogs consumed on farms.

HISTORY OF HOG PRODUCTION IN KENTUCKY

In 1870 Kentucky was one of the leading hog-producing states; 7.3 percent of the hogs in the United States were located within its borders. Since that year its importance has steadily declined until, in 1930, only 2 percent of the nation's hogs were produced in the State. The largest decline occurred between 1870 and 1880, while

1 Acknowledgement is made to H. B. Price, Head of the Department of Markets and Rural Finance, for assistance and suggestions given during the collection and analysis of the data and the preparation of the manuscript. Also to H. G. Sellards, Field Agent in Animal Husbandry, and to G. B. Byers, Assistant in Farm Management, for their suggestions; and to the Livestock Auction Market Companies, the Stockyards Companies and Packing Plants who by making their records available made this study possible.

2 Farm Value, Gross Income and Cash Income from Farm Production, published by the U. S. Department of Agriculture, Crop Reporting Board, and Farm Production and Income from Meat Animals, 1924-1935, published by Crop Reporting Board, U. S. Department of Agriculture.

between 1910 and 1930 the decline amounted to only one-half of one percent.

The proportion of hogs located in Kentucky has increased since 1930 nearly one percent. This increase is not because of an actual increase in number of hogs in Kentucky, but because of a decline in hog production in sections of the United States where commercial

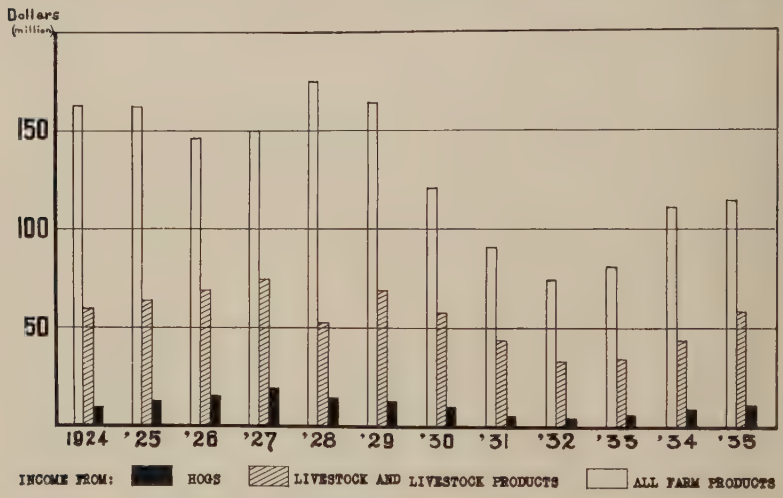

FIGURE 1. Total cash income from all farm products, from livestock and livestock products, and from hogs, in Kentucky.

hog production predominates. It can be safely assumed, therefore, that in regard to the proportion of total number of hogs produced in the United States, the hog enterprise in Kentucky has become fairly well stabilized.

Over 75 percent of the hogs produced in the United States in 1860 were east of the Mississippi, approximately 25 percent in the East South Central States, another 25 percent in the East North Central States and the remaining 25 percent along the Atlantic seaboard. During the subsequent 30-year period the West North Central States, with an increasing farm population and rapidly expanding acreage of corn, gained in proportion of hogs at the expense of both the East South Central and South Atlantic sections. The East North Central section maintained its position.

This tendency toward concentration in the western part of the

corn belt continued after 1890 so that by 1930, 49 percent of the nation's hogs were produced in this area. This concentration is shown in Figure 2. The increase in corn production and the expansion of dairying in the West North Central States were the most important factors leading to this concentration. Altho hog production declined in all sections of the United States except the West South Central region, during the next five year period, the decrease was much more rapid in the West North Central region. This re-

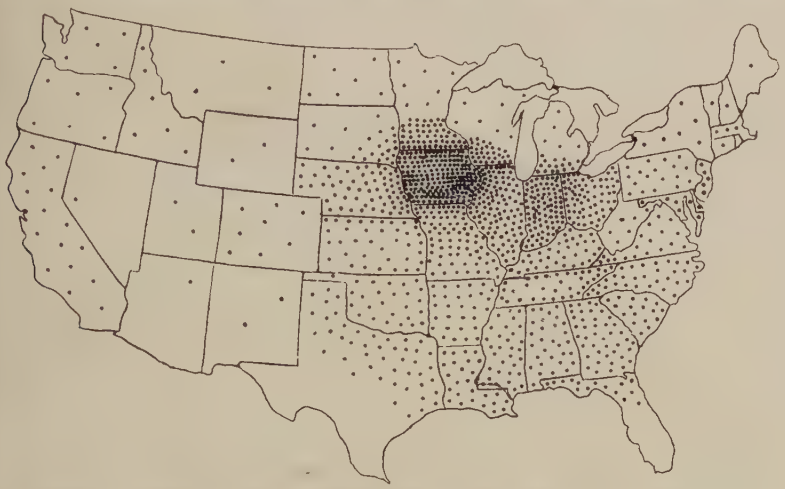

FIGURE 2. Number of swine on farms January, 1935. One dot equals 30,000 head.

sulted in an increase in the proportion of hogs raised in all sections except the West North Central states where, by the year 1935, only 36 percent of the national supply was produced, and in the mountain regions, where production remained practically constant. This decrease was caused by adverse production conditions, unfavorable price relationships with other farm products, and the corn-hog adjustment program. In the East South Central region of the United States, where Kentucky is located, the only increase of any importance occurred in Mississippi. These recent shifts in the proportion of hogs produced in the various regions are in all probability only temporary and, with favorable conditions in the West North Central region, that section may again assume the position in hog production that it formerly held.

Hog production in Kentucky has increased since 1890, in four parts of the State. The areas of concentration are shown in Figure 3; (1), part of type-of-farming area No. 7,[1] comprising Henderson, Union, Daviess, Webster and McLean counties; (2), part of type-of-farming area No. 8, comprising Ballard, Carlisle, Hickman, and Fulton counties; (3), part of type-of-farming area No. 5, comprising Barren, Warren and Simpson counties; and (4), the southern part of type-of-farming area No. 3, comprising a larger area extending southeast from Louisville across the southern part of the Bluegrass area.[2] In the remainder of the State, hog production has declined. Only in the first three of the above districts, however, are hogs produced on a commercial scale approaching the level of production

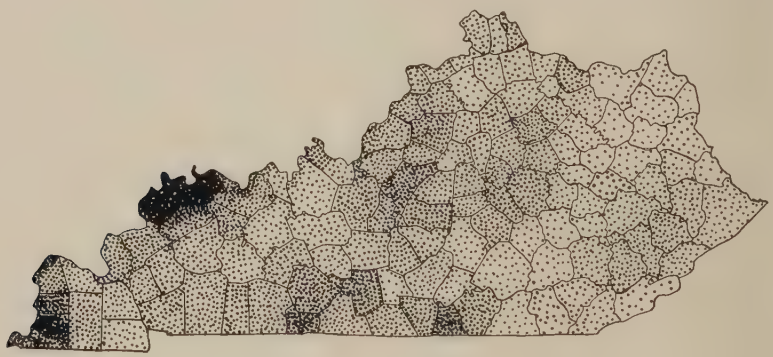

FIGURE 3. Number of swine on farms in Kentucky January 1, 1935. One dot equals 200 hogs.

in the Corn Belt States. It is the purpose of this study to ascertain the nature of the changes mentioned and to show the principal price relationships that have caused the hog enterprise in Kentucky to assume its present level of importance.

There has been a general tendency during the past fifty years for the production of hogs to be concentrated in the area in which corn production is largest. This has also been the case in Kentucky, especially since the beginning of the present century. (See Figure 4.) There are several districts, however, in which the production of

1 For a complete description of areas see Types of Farming in Kentucky by Bruce Poundstone and Walter Roth, Kentucky Agricultural Experiment Station Bulletin No. 357.

2 Including counties of Jefferson, Oldham, Bullitt, Spencer, Shelby, Nelson, Larue, Washington, Mercer, Boyle, Lincoln, Jessamine, Garrard and Madison.

corn is considerably more concentrated than is the production of hogs. This can be explained by the fact that farmers in those areas are producing other types of livestock, principally cattle, to which corn is fed. Some of the surplus corn produced in these areas is also sold as cash grain in the bordering hog-producing counties. The amount of corn produced in any section and the availability of other feed to supplement it, accounts to a large extent for the number and the type of hogs produced in the various districts.

FIGURE 4. Corn production in Kentucky in 1934. One dot equals 20,000 bushels.

Table 1. Percent of hogs in different weight groups at Central Kentucky auction markets. Average for 1931-1935.

MONTH	Below 100 pounds	100 to 139 pounds	140 to 159 pounds	160 to 199 pounds	200 to 219 pounds	220 to 269 pounds	Above 270 pounds
January	31	23	10	17	10	7	2
February	33	25	9	16	10	5	2
March	24	21	10	19	15	9	2
April	17	17	10	24	19	11	2
May	11	14	12	27	22	12	2
June	13	14	12	25	22	11	3
July	26	12	9	21	17	13	2
August	26	15	9	21	16	10	3
September	25	19	11	24	13	6	2
October	23	18	11	24	15	7	2
November	22	20	10	23	15	8	2
December	25	20	12	20	13	7	3
Average	23.0	18.2	10.4	21.8	15.6	8.8	2.2

In the Bluegrass region of Kentucky, where the production of hogs is comparatively heavy in relation to the production of corn, less than one-half of the hogs marketed are finished to slaughter

weight. A very large proportion of hogs marketed in this section are sold at light weights. This is shown by an analysis of the weights of 534,806 graded hogs sold at the leading auction markets in the district. During the five-year period (1931-35, inclusive) 51 percent, or 272,147 head, weighed less than 160 pounds. The other 262,659 head, or 49 percent, were of slaughter weight. Detailed information is shown in Table 1. In addition to this large number of light-weight hogs, many small pigs were sold that are not included because they were sold as litters at some of the markets, and the number of pigs sold with a sow was not always recorded. It must be recognized that some of the light-weight hogs, especially those between 140 and 160 pounds, are slaughtered, while some hogs weighing more than 160 pounds are sold as feeders.

This situation varies somewhat from year to year, usually reflecting the production of corn. For example, in 1935, when corn production was large, the number marketed weighing below 100 pounds dropped over two percent below normal while all other weight groups except the 140-160-pound group, increased. The principal reasons that so large a percentage of hogs produced in this area is not finished to heavier weights are the lack of locally-produced corn and the competition of other types of livestock more suitable to utilize pasture as well as the corn that is produced. Many farmers who have abundant pasture in the spring and fall produce more pigs than they are able to fatten with the amount of feed produced; thus only those which are needed to supply home meat or to utilize home-grown feeds are fattened, while the remainder are sold as feeder pigs. By following this method farmers in this area are able to utilize available farm feeds and secure an income from the sale of light-weight hogs.

The time when light-weight hogs are marketed shows considerable variation from the time when slaughter hogs are sold. (See Figure 5.) As it was found that the seasonal movements of the three light-weight groups, or hogs weighing less than 160 pounds, were similar they were combined into one group for this part of the study. Altho marketings of this class did not vary greatly during the first seven months of the year, there was a downward trend, followed by a sharp increase during August and September, reaching a peak in

October and November, after which marketings dropped rapidly during December.

All weights of slaughter hogs had a different seasonal movement from that of light-weight hogs but followed each other rather closely.

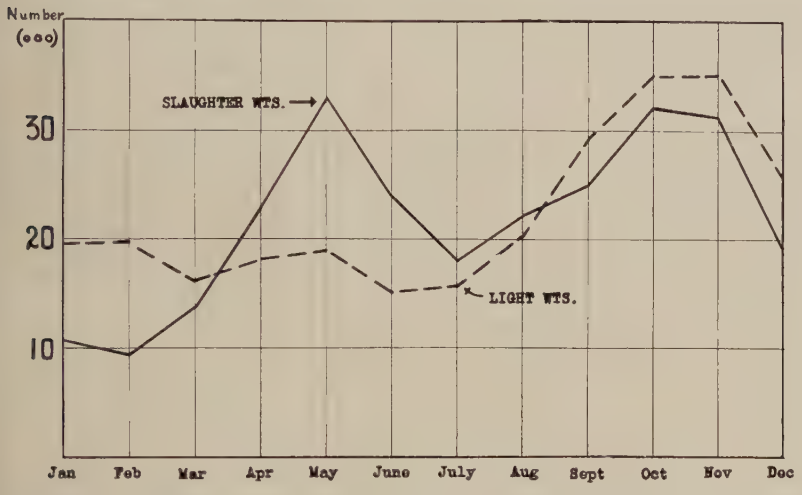

FIGURE 5. Monthly marketing of light-weight and slaughter-weight hogs in Central Kentucky, 1931-1935.

The marketings of slaughter hogs declined slightly from January to February after which there was an increase to spring peak in May. During June and July there was a decline followed by increased marketing during the next three months to a fall peak in October and November. Marketings then declined rapidly during December as is shown in Figure 5.

The demand for feeder pigs is greatest in the fall at which time the condition of the feed crops is definitely known by farmers in this section, who purchase feeder pigs to follow cattle in feed lots, and also by farmers in the corn-producing states to the north, where a large number of the feeder pigs produced in this section are sent for fattening. Many light-weight hogs produced in this section are also purchased by serum-producing plants in the north and east. This demand is not so seasonal as the feeder demand and lasts thruout the year. Many farmers purchase a few feeders in the spring to fatten for home use, rather than produce pigs on their farms, main-

taining that it is cheaper to buy the feeders desired than to keep a sow the year around for the production of pigs to fill home meat requirements.

Many light-weight hogs sold in this region in the fall are from spring pigs grazed on bluegrass pasture; having been fed a minimum of grain, they are not in slaughtering condition. This fits into the method of production followed on many farms in Central Kentucky, because of the shortage of corn or concentrated feeds produced on them and the large acreage of bluegrass pasture.

The average weight of hogs marketed in the Bluegrass Region of Kentucky is considerably lower than at any of the terminal markets for which records are available. The monthly average weight of hogs received at Chicago during the five-year period, 1931-1935, inclusive, varied from 68 to more than 100 pounds heavier than the monthly average weight of hogs marketed in the Bluegrass Region.

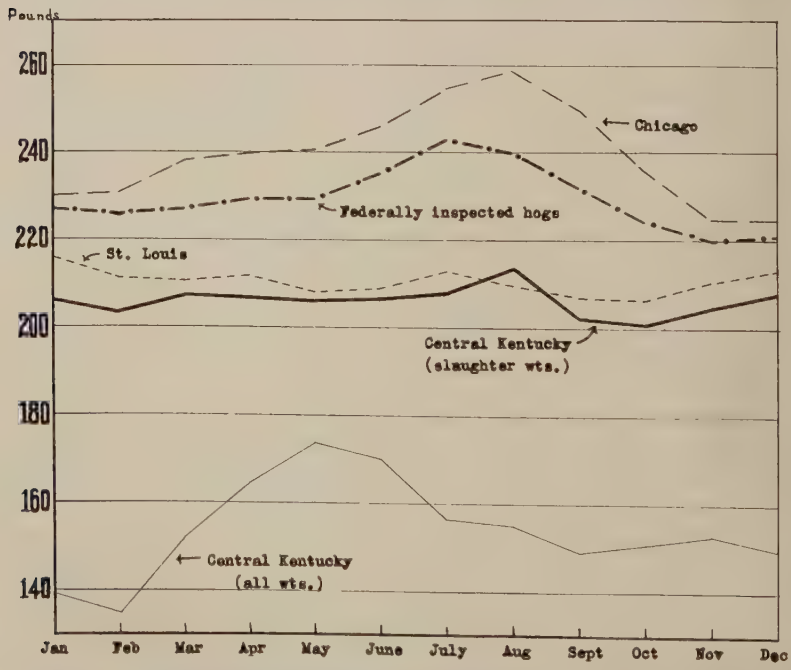

FIGURE 6. Average monthly weight of hogs marketed at various terminal markets, hogs slaughtered under Federal inspection, and hogs marketed in Central Kentucky, during 5-year period, 1931-1935.

At St. Louis, where the average weight was from 34 to 77 pounds heavier than at the Kentucky auction markets, the average weight of hogs received was lighter than at most terminal markets. These comparisons are shown in Figure 6. When the average weight of only the slaughter hogs, or those weighing over 160 pounds, was compared with the average weight of all hogs at the terminal markets, it was found to be several pounds less.

It should be pointed out, however, that the receipts at the Kentucky auction markets and the terminal markets are not exactly comparable, as hogs sent to the terminal markets are, to a large extent, slaughter hogs while at the auction markets 51 percent are feeder pigs. But if the feeder pigs are eliminated from the auction market receipts, the average weight of the remaining, or slaughter weight, hogs is considerably below the average weight of all hogs marketed at the terminals. This is shown more clearly by the fact that 91 percent of all hogs marketed thru the auction markets of Kentucky weigh less than 219 pounds. This situation reflects the small production of corn in this area and shows that the production of light-weight hogs competes favorably with the production of other types of livestock, while the fattening of hogs for slaughter is less profitable than the production of other types of livestock, which can utilize more pasture.

In the South Central section of the State the hog enterprise is not handled in the same way as in the Bluegrass Region. Corn is produced in much larger quantities while other types of livestock are not produced so extensively. Consequently, hogs are generally grown to slaughter weights. In fact the number of pigs is often not sufficient to utilize the local corn crop and many farmers of this area purchase feeder pigs, usually from southern states, to utilize surplus feeds.

Data on the weights of hogs marketed from this area were not as complete as for the Bluegrass Region. However, data were secured on the sale of 24,453 hogs from this territory during the period, 1932 to 1935, inclusive. The average weight of hogs sold during this four-year period was lower than that on many of the terminal markets. The average weight of the 24,453 hogs was 207.5 pounds while the average weight at Chicago was 239 pounds, at Kansas City

226 pounds and at St. Louis 211 pounds. The general seasonal movement of hogs to market by weight group corresponds very closely to that of a typical corn belt market as is illustrated in Figure 7. This is to be expected as the hog enterprise in this area is conducted similarly to that in the corn belt states.

The hog enterprise in the other two areas of concentrated production, the Evansville territory and the western part of the Purchase, is quite similar to that described for the South Central district. The weights to which hogs are finished for market and the season at which hogs of different weights are marketed are quite similar as is shown in Figure 7. Data for the marketings of hogs at Owensboro are based on the record of sales of 82,875 hogs during the years 1931-1935, while at Henderson, data are based on the record of sales of 111,351 during the same 5-year period.

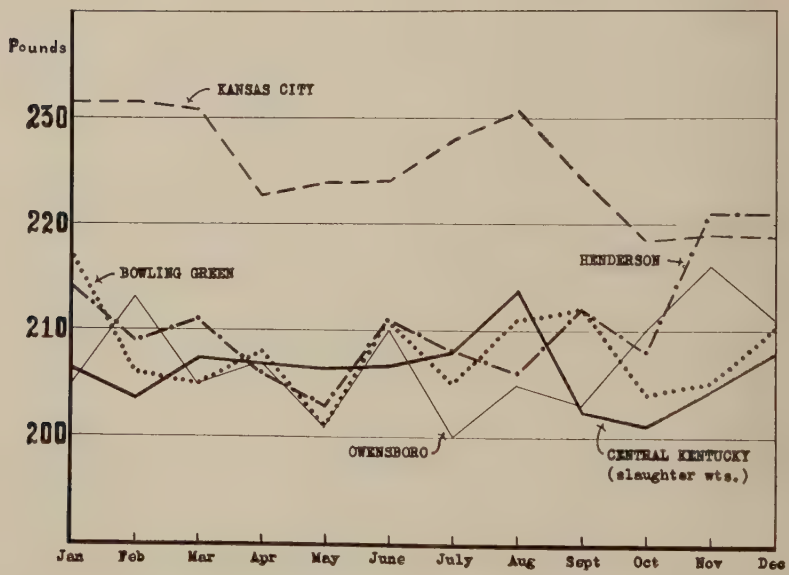

FIGURE 7. Average monthly weight of all hogs sold at various Kentucky markets and slaughter weights in Central Kentucky during the 5-year period, 1931-1935.

The hog enterprise on farms in the territory lying between these regions of concentrated hog production and in the entire eastern or mountainous section of the state takes a position of minor import-

ance. On most of these farms only enough hogs are raised to supply the family meat requirements. In much of this territory feeder pigs are shipped in to supply the demand or a few favorably located producers raise a surplus of pigs to supply neighbors. Hogs are fattened on kitchen slop and such other feeds as are available, with only a limited amount of corn used in finishing them as corn production is small. Hogs in this territory are normally kept until they are heavier than is usual in most areas, in order to furnish as much lard as possible, in addition to meat, for supplying household needs.

MARKET OUTLETS

Kentucky hog producers are fortunately located in relation to markets. Nearly all sections have access both to terminal markets and to such local markets as auctions, packing plants, local butcher shops, and country traders. Not all these outlets are available to all producers of livestock but since most farmers who have hogs to sell have a choice of means of disposal, method of sale depends largely upon the availability of market outlets, the type of hogs produced or the individual preference of the producer.

By far the largest number of hogs marketed from Kentucky in 1935 were sold at Louisville, Evansville, and Cincinnati. During 1935, 149,039 head of hogs produced in Kentucky, were marketed at Louisville, 121,850 at Evansville, and 38,009 at Cincinnati. These three markets, better located to serve Kentucky hog producers than any of the other terminal markets, handled the largest percentage of hogs marketed from the State. No figures were available for Nashville or St. Louis, the other conveniently located terminal markets. According to reports received from the U. S. Department of Agriculture, the twelve terminal markets, Buffalo, Chicago, Cincinnati, Cleveland, East St. Louis, Evansville, Indianapolis, Jersey City, Louisville, Nashville, Pittsburg, and Baltimore handled 522,000 hogs shipped from this State during 1935.

Terminal or primary markets furnish an outlet for all hogs produced in the State altho in many sections secondary market outlets have developed which, in many cases, lessen the need of terminal markets and furnish an outlet for livestock much closer to the point of production. Many hogs which finally reach the terminal markets were shipped there directly by producers while many have

already passed thru some of the secondary markets, such as local auction markets, local packing plants or country traders, which have performed the service of collecting the hogs for shipment. The extent of the movement thru the secondary markets prior to shipment to terminals, however, could not be determined.

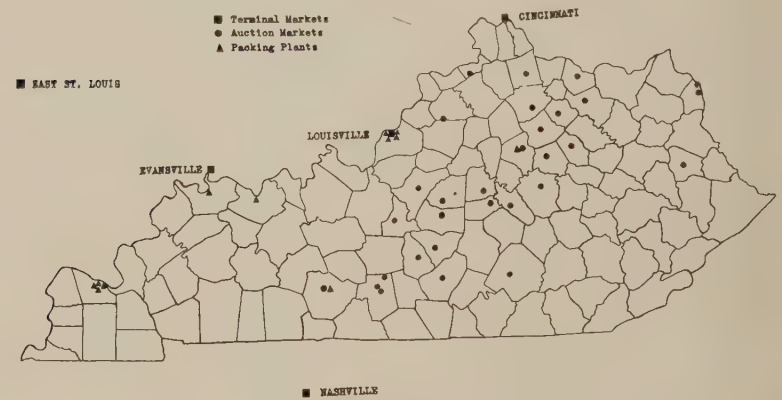

FIGURE 8. Various types of livestock markets in Kentucky.

The most complete system of secondary markets in the State has developed in the Bluegrass Region where, in 1935, about 275,000 head of hogs were sold at the thirty livestock auction markets. The location of these is shown in Figure 8. They are in production areas and serve as concentration points in assembling hogs for shipment to eastern packers or to terminal markets. Furthermore, they serve as distributing centers for the feeder classes of hogs produced in the territory, as only a small percentage of this type of hogs is sold thru the terminal markets.

Kentucky hogs sold thru the local auction markets have a comparatively wide distribution. Except sows with pigs and breeding stock, more than one-half of the hogs sold at the auction markets during the period, 1931 to 1935, were classed as feeders or light-weight hogs. Part of these light-weight hogs were returned to the country in the immediate vicinity, part were shipped to important corn-producing areas in Ohio, Indiana and Illinois, and part were sold to serum plants in Indiana, Ohio and Eastern States. Fat or slaughter hogs were purchased by order buyers representing packers

in the large consuming centers, local slaughter houses, speculators who ship to terminal markets, or by local butchering establishments.

Local packing plants are another type of secondary market which has developed in the more concentrated hog-producing areas of the western part of the state. The sale of hogs by farmers directly to packers has not developed in Kentucky to the extent that it has in many other parts of the United States. The development of local or independent packing plants has not shown any significant increase in recent years. The supply of slaughter hogs in most sections of the State is not of sufficient volume to warrant their establishment. There are, however, twelve packing plants in Kentucky that purchase their supply of slaughter hogs, either wholly or in part, directly from farmers. That the direct purchase of hogs from producers is increasing in Kentucky is shown by the fact that most of these plants have increased the number of hogs purchased directly from the producers during the last several years.

Nine packing plants in Kentucky, which buy their supplies directly from farmers, slaughtered about 97,200 hogs in 1935. In several of these plants, however, the slaughterings do not represent the total number of hogs purchased from farmers, as they buy all the livestock offered them. If more hogs are purchased than are required to meet local slaughter demands, they are shipped to terminal markets, Evansville, Louisville, and Cincinnati receiving the bulk of such shipments. A surplus of hogs is received only during the short period when most of the locally-produced hogs are marketed, while at others it may become necessary for the plants to purchase hogs in outside markets to meet local requirements.

Other packing plants follow the practice of purchasing from producers only their slaughter requirements. When these have been met they stop buying, temporarily. Some of the smaller plants require farmers to list stock for sale several days in advance of delivery and in this way regulate the supply of hogs to slaughter demand. On days when the listed supply does not meet requirements, the managers telephone to local represntatives in producing communities either to purchase or solicit a sufficient number of hogs to fill their needs. The plants operating in this manner found it very satisfactory, altho the managers of the three plants which buy all live-

stock brought to them stated that they found it necessary to operate in this manner or the producers who failed to sell their stock would look elsewhere for regular outlets and thus the demand for livestock could not be met during periods of small marketings. In markets where there were other outlets, however, packers did not feel obliged to purchase more than the day's requirements and, as farmers have become accustomed to this method, it appears to be working satisfactorily for both the plants and the producers.

Another type of direct purchasing that developed during the depression years was the method of merchandise exchange. Packing plants made arrangements with local meat markets or country stores to buy hogs from farmers, paying for them in merchandise. The packer then purchased the hogs from the local concern and paid for them with packing-house products. This form of marketing hogs showed considerable growth for a period but has since declined and at present is practically extinct. During the depression years, when money was relatively scarce, it served a distinct purpose.

In recent years many local butchers in small towns have again started purchasing sufficient hogs to meet their requirements for fresh pork. These butchers, who formerly depended upon large packing plants to supply their needs, have endeavored to reduce their costs by slaughtering hogs purchased directly from the farmers. In many localities this furnished a direct market for a limited number of hogs.

All the methods developed in the State, in which producers sell directly to the processor, furnish an outlet for fat hogs only and consequently have developed only in those areas where most of the hogs produced are fattened. In these areas, however, very few feeder pigs are sold so that there is a very limited need for a market outlet for them.

PRICES

Price data on the sale of hogs at Kentucky markets are available for only the last few years, but during that time hog prices in this State followed closely in line with the terminal market prices which are illustrated in Figure 9; the seasonal relationship is illustrated in Figure 10. Price fluctuations in Kentucky are chiefly a reflection of price variations at the terminal markets.

Hog prices show three rather distinct characteristics—long-time trend, seasonal fluctuation, and a fairly regular cyclical movement.

Long-time trend of hog prices. Altho the actual prices of hogs showed a considerable upward trend from 1903 to 1919, there was only a small upward trend in the purchasing power of hogs during this period, as not only the price level of hogs, but of all other commodities rose at approximately the same rate. Since 1919, however, the price of hogs has fallen more rapidly than the prices of other commodities so that there has been some decrease in the purchasing power of hogs during this period. In 1919, when hogs sold for an average of $17.00 per 100 pounds, the purchasing power was not much more than when hogs sold for $8.90, in 1910. Actual prices of hogs are illustrated by the solid line in Figure 9. The deflated price, represented by the dotted line in Figure 9, shows the price of hogs after a correction has been made for changes in the general price level. The deflated price was computed by dividing the actual average yearly price of hogs at Chicago by the index number of prices of all commodities[1] for the corresponding year. Thus fluctuations due to changes in the general price level are largely eliminated and the result indicates what would have been the price had the general price level remained at about the level of 1910-1914. Deflated hog prices averaged $8.76 for 1919, while in 1910 the average was $8.67 showing that even with price at a much higher level during 1919 than during 1910, there was really very little difference in the purchasing power of hogs.

Seasonal fluctuation of hog prices. Hog prices tend to follow rather definite seasonal trends. During the months of increasing hog receipts, prices tend downward, while in periods of decreasing receipts prices tend to rise. Thus, during May and June, when the bulk of the fall pig crop is marketed, and again in October, November and December, when the largest proportion of the spring crop of pigs is sold, prices normally are low. On the other hand, during March and April and again in July and August, when market receipts of hogs are relatively small, prices tend to be higher.

Cyclical movement of hog prices. There have been 12 distinct upward and downward movements in the price of hogs during the

1 Wholesale prices of all commodities published monthly by the U. S. Department of Agriculture.

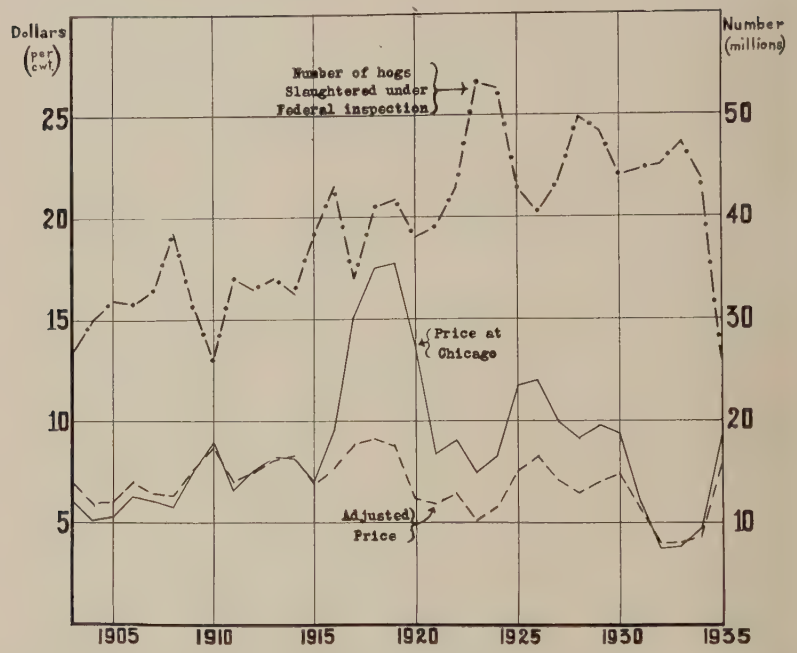

FIGURE 9. Prices of heavy hogs at Chicago, prices of hogs expressed in terms of 1910-1914 dollars, and number of hogs slaughtered under Federal inspection, in the United States.

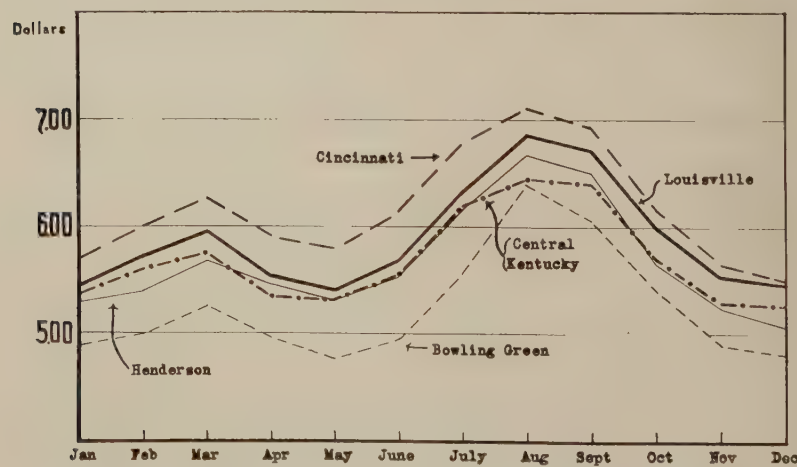

FIGURE 10. Average price by months of 180-240 pound hogs at Cincinnati and Louisville, 160-240 pound hogs in Central Kentucky, and hogs purchased for slaughter at Bowling Green and Henderson, 1931-1935.

past 70 years. These movements, commonly referred to as cycles, vary somewhat in length of periods between high or low points of prices but, on the average, prices increased for 36 months and declined for 31 months. The last peak was reached in 1929. The severe drop in the prices of all commodities, which occurred in the latter part of 1929 and all of 1930, caused the upswing in the price cycle, which started in 1928, to be much shorter than normal. Following the low point in 1932, the prices of hogs tended to rise.

Several causes are responsible for price cycles, but increase and decrease in production are the main factors. This is clearly shown in Figure 9 where the number of hogs slaughtered under Federal inspection is shown with the price of hogs since 1903. Except the period of the world war, whenever the slaughter of hogs was large, prices were low. During periods of high prices more producers went into hog production and those producers already in the business increased production. On the other hand, when hog prices were low some producers curtailed production and others liquidated entirely.

Relationship of prices on various markets used by Kentucky hog producers. Prices paid farmers for hogs in different sections of the state differ somewhat, but they usually show a rather definite relationship to certain terminal markets. At the terminal markets serving Kentucky producers, the prices paid were highest at those closest to the consuming centers or those farthest east. For example, the 5-year (1931-1935) average price of slaughter hogs at Cincinnati was $6.17 while at Louisville the average price was 28 cents lower, or $5.89. These differences, shown monthly, in Table 2, represent to a large extent the difference in cost of transportation to the eastern consuming centers.

Prices at the auction markets in Central Kentucky likewise averaged lower than those at Cincinnati. Prices on the top grade varied from 31 to 62 cents below Cincinnati prices and averaged for the 5-year period, 1931-1935, 49 cents lower. Prices at Henderson and Bowling Green, however, are not exactly comparable to those at Cincinnati or in Central Kentucky as they are paid by local killing plants for hogs purchased for slaughter only. Furthermore, there are no marketing costs other than transportation, since hogs are sold directly to packers, while at the other markets there were charges

for selling. Hogs at Henderson and Bowling Green sold for prices under those at Cincinnati or Louisville, At Henderson prices averaged 52 cents for the 5-year period, 1931-1935, and at Bowling Green, 95 cents below the price at Cincinnati. These margins between local and terminal market prices reflect market and transportation costs between the two markets. The variation in prices paid at the various markets discussed are illustrated in Figure 10.

Table 2. Average monthly price of slaughter hogs at Cincinnati, and the average difference in price as paid on various other markets, 1931-1935.

MONTH	At Cincinnati dollars	Amount in cents below the average price at Cincinnati, at Louisville Auction Markets	Henderson	Bowling Green
January	5.70	25	33	42	82
February	6.10	37	51	72	111
March	6.29	34	54	62	104
April	5.92	38	56	58	96
May	5.81	39	49	48	104
June	6.15	44	59	62	120
July	6.75	39	56	59	118
August	7.07	20	62	40	88
September	6.92	19	52	43	86
October	6.12	12	43	47	72
November	5.68	13	37	44	79
December	5.58	11	31	51	76
Average	6.17	28	49	52	95

Local packers not only vary the prices paid for hogs as terminal market prices vary but they also vary the margins. By narrowing the margin between terminal market prices and local prices more hogs are attracted to the local plants while by widening the margins more hogs are taken to other markets. Thus by regulating the margin local packers can, to some extent, regulate supplies in order to meet the demand more closely. Thus by an examination of Figure 10 and Table 2, it can be seen that there are seasonal variations in the margins. They are wide in the spring and summer and narrow in the fall and winter. These variations are made to attract more hogs to the local market during the winter, when marketing is made difficult by inclement weather, muddy roads and the press of other farm work. In the spring and summer, more hogs are brought to the local markets than can be used for local slaughter demands, so by

widening the margin the local market is made less attractive and more hogs are taken to other markets.

A study was made of the prices paid for 534,806 graded hogs sold at five auction markets in Central Kentucky, during the five-year period, 1931 to 1935, inclusive. Data were classified according to weight of hogs in order to discover the variation in prices paid for hogs of different weights. It was found that prices fell into six groups according to the weight of hogs: below 100 pounds, 100-139 pounds, 140-159 pounds, 160-199 pounds, 200-219 pounds, 220-269 pounds, and above 270 pounds. The average prices of the various weights is given by months in Table 3.

Table 3. Average monthly prices of various weights of hogs sold on the auction markets, 1931-1935.

MONTH	Below 100 pounds	100 to 139 pounds	140 to 159 pounds	160 to 199 pounds	200 to 219 pounds	220 to 269 pounds	Above 270 pounds
January	$4.93	$4.64	$5.09	$5.00	$5.18	$5.19	$5.22
February	4.72	4.66	5.09	5.40	5.61	5.27	5.06
March	4.66	4.76	5.34	5.57	5.72	5.77	5.05
April	5.03	4.71	4.85	5.21	5.28	5.00	4.44
May	5.15	4.89	4.87	5.20	5.28	5.48	5.13
June	5.07	4.66	4.86	5.36	5.58	5.85	5.42
July	5.81	5.85	6.00	6.08	6.52	6.34	5.90
August	5.72	5.65	5.91	6.38	6.38	6.21	6.72
September	5.27	5.47	5.78	6.14	6.17	6.27	5.98
October	4.70	4.98	5.37	5.59	5.58	5.69	5.83
November	4.83	4.75	4.96	5.19	5.11	5.26	5.44
December	5.60	5.24	5.39	5.42	5.49	5.36	5.94
Average	$5.11	$5.00	$5.27	$5.55	$5.63	$5.66	$5.58

Prices of some of the grades varied considerably in relation to other grades during the different years. These price variations are shown in Figure 11. During the first two years studied, the light-weight hogs brought the higher prices. This can be explained primarily by the reaction of farmers to the price cycle which was at a peak in 1929. Hog producers were building breeding herds during the next two years, and many farmers who had been forced to liquidate herds during the drouth of 1930 were again going into hog production. Also feed was relatively plentiful and it was profitable to feed hogs, consequently the demand for feeders was so great that prices of light-weight hogs were higher than those of heavier hogs.

On the other hand, during the next two-year period the hog enterprise was less profitable and many producers were curtailing production in response to low hog prices, drouth of 1934, and the National Corn-Hog Adjustment Program. The demand for light-weight hogs for replacement or feeding was at a low level. This condition caused slaughter grades of hogs to sell at a premium over the lighter weights. Conditions might have been reversed again in 1935, because of the upturn in the price cycle which occurred in that year, but wide-spread drouth in 1934 caused a shortage of feed and reduced the demand for feeders and light-weight hogs for herd replacements.

The weight to which it is most profitable to finish hogs for market in this section varies from year to year. With the relatively small price differential paid for hogs of different weights, the availability and price of feeds is an important factor in determining to what weight hogs should be finished for market. Market price, which

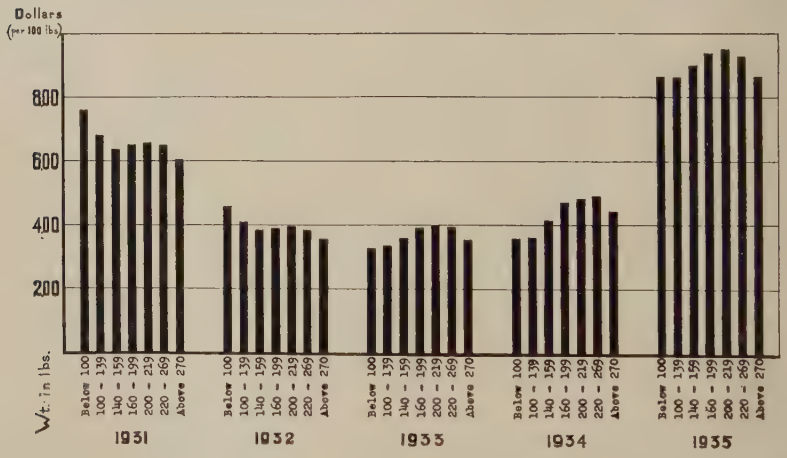

FIGURE 11. Prices paid at the auction markets for hogs of different weights during the years 1931, 1932, 1933, 1934, and 1935.

reflects the demand situation, either for heavy finished hogs for slaughter or light-weight hogs for feeding and herd replacement, is also a factor which cannot be overlooked in determining the weight at which hogs should be marketed.

Individual farmers are interested in marketing hogs at the weight

which returns the largest net income. In order to secure the largest net income from the hog enterprise, they may find it necessary to vary the weight at which hogs are marketed from year to year, because of the changing relationship of the above factors to one another and because these factors vary widely from year to year.

HOG–CORN PRICE RELATIONSHIPS

Concentrates usually constitute the main item of expense in fattening hogs for market; in Kentucky, as in other mid-western states, the main concentrate used is corn. Since corn is the chief hog feed, the hog-corn ratio[1] is probably the best average measure of the profitableness of the hog enterprise that is now available. Farmers tend to increase hog production when the feed supply is plentiful and the price of corn is low in relation to the price of hogs, and to decrease production when the situation is reversed. It was impossible to figure hog-corn ratios for each county but three hog-corn ratios for different conditions in Kentucky were figured; first, for an area where more corn is produced than is consumed locally and hog production is a main farm enterprise; second, for an area where insufficient corn is produced for local requirements and relatively few hogs are produced: and third, for an area where insufficient corn is produced for local requirements and hog production is relatively important. The three hog-corn ratios are shown in Figure 12 with a comparison of the hog-corn ratio in Iowa and at Chicago.

The hog-corn ratio representing the surplus-corn-producing sections of the State was worked out for Union county.[2] It was found that the five-year average (1931-1935) hog-corn ratio was 12.62 for this district, as compared with 10.35 for Chicago[3] and 12.68 for the State of Iowa.[4]

These hog-corn ratios indicate that hog production in Union county is as profitable as it is in Iowa. This is more or less borne out by the number of hogs produced in Union county, which is

1 The term "hog-corn ratio" as used in this bulletin refers to amount of corn that 100 pounds of live hogs will purchase.

2 The hog-corn ratio in Union county was calculated by dividing the average monthly price paid for hogs at Henderson by the average monthly price paid for cash corn at the grain elevator in Uniontown.

3 The hog-corn ratio for Chicago was based on the average price of heavy hogs at Chicago and the average price of No. 3 yellow corn at the same market.

4 The hog-corn ratio for Iowa was based on the average price of hogs and corn as published by the Agricultural Experiment Station, Iowa State College of Agriculture and Mechanic Arts, in Bulletin 336, Index numbers of Iowa Farm Products Prices and Mimeographed Supplement to Current Economics Series, Report No. 3.

comparable to that of a typical county of equal size in Iowa. That the ratios show some variation is true but crop conditions in one section or the other cause some variation in prices. Furthermore, the price of corn in Union county varies somewhat more than does the price of corn in Iowa.

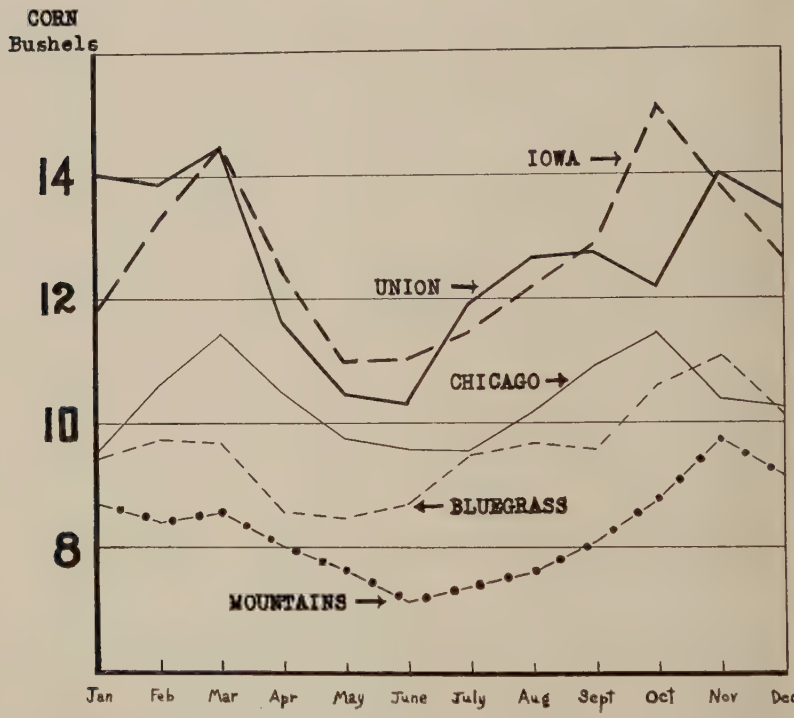

FIGURE 12. Hog-corn ratios at various points in Kentucky, at Chicago, and in Iowa, average 1931-1935.

The hog-corn ratio[1] in the Bluegrass area of Kentucky where hog production is heavy in comparison with the production of corn, averaged 9.59 (See Figue 12) or 3.03 points below the ratio in Union county. This explains to a large extent why such a large proportion of the hogs of this section, as is shown in Table 1, were marketed as

1 The hog-corn ratio in the Central Bluegrass area was based on the average price of slaughter-weight hogs sold at Lexington and the average price received by farmers for corn in Crop Reporting district No. 5, as reported to the United States Department of Agriculture.

light weight or feeder pigs. This condition also explains why the hog enterprise in the Bluegrass area has failed to be maintained at the level that existed late in the 19th century. As was previously pointed out, the hog enterprise in this section takes the form of producing feeder pigs, and only enough hogs are fattened to consume locally-produced feeds or to utilize waste in feeding cattle.

Another hog-corn ratio was computed[1] for the mountain region, a strictly deficient corn area where few hogs are sold and where those that are produced are used to furnish a meat supply for the farm family. In this district the hog-corn ratio averaged 8.26 for the 5-year period, 1931 to 1935 (See Figure 12), or 4.36 below Union county and 1.33 below the Bluegrass area. One of the main reasons that hog production in this area has not developed to the extent that it has in the Bluegrass area, altho the hog-corn ratios are not so different, is the lack of good pastures for ranges for pigs and the higher cost of producing corn or other feed grains. As few cattle are fattened in this area, as compared with the central part of Kentucky, there is also no place for hogs in the feed lots to utilize waste feeds.

If Kentucky hog producers are to make use of this valuable measure of the profitableness of the hog enterprise, it is necessary for them to get some idea as to the relationship of the hog-corn ratio which exists in their locality to the ratio at Chicago. This ratio, based on the average price of hogs and of No. 3 yellow corn, both at Chicago, averaged 11.5 during the last 50 years. While the hog-corn ratio at Chicago is usually lower than one in a producing area because the costs of marketing are included, nevertheless, it is used as a standard for all districts as it directly reflects conditions existing in the producing areas. Generally speaking, farmers tend to increase hog production when the hog-corn ratio at Chicago is greater than 11.5, while on the other hand, they tend to decrease the hog enterprise when the ratio falls below that figure. Furthermore, as the price of hogs usually follows a rather definite seasonal trend as also does the price of corn, it naturally follows that the hog-corn ratio shows a definite seasonal trend. The price of corn is normally

1 In the deficit corn area of the State the hog-corn ratio was calculated on the basis of average prices received by farmers for hogs and corn in Crop Reporting District Number 6 as reported to the Division of Crop and Livestock Estimates, U. S. Department of Agriculture.

lowest in the late fall and winter and highest during the summer. On the other hand, as was previously pointed out, hog prices are highest in the late summer, and low in the late spring and fall. This situation results in a high hog-corn ratio during February and March and again in October and November, during which it is relatively more profitable to feed hogs than during the period of low hog-corn ratios which occurs during the summer. Consequently, feeding operations in Kentucky can be carried on more cheaply from September to March than during the period April to August. It must be recognized, however, that feeds other than corn on which to fatten hogs are used in the State. But the practice is so limited that where other feeds are used as the basis for the fattening ration, local conditions must determine the profitableness of the hog enterprise.

SUMMARY

The swine enterprise on Kentucky farms during the past 12 years accounted for an average of 8.5 percent of the total cash income received by farmers. For the same period, the income from hogs also amounted to 19 percent of the total cash income received from livestock and livestock products. In addition to the cash income the value of hogs slaughtered on farms for home meat during the period averaged nearly 10 million dollars or 47.4 percent of the gross income received from hogs. Even with the hog enterprise furnishing this proportion of the income on Kentucky farms, it can be classed as a major farm enterprise only in a few counties of the State, while in the remainder of the State, it takes the form of a side line or minor farm project.

Hog production appears well stabilized in Kentucky at the present time. The number of hogs produced in Kentucky has declined steadily since 1870. The largest decline occurred between 1870 and 1880, while between 1910 and 1930 the decline amounted to only one half of one percent. In 1870, 7.3 percent of the nation's hogs were located within the State. By 1930, the proportion had declined to two percent. Since 1930, the proportion of hogs in Kentucky has increased slightly, while in other areas there has been a decrease. This situation is perhaps only temporary and was caused by recent widespread drouths in other important producing sections.

The distribution of hog production in Kentucky has changed rather markedly since 1870. Since 1900 the production of hogs on a commercial scale has centralized in the following areas: (1) Henderson, Union, Daviess, Webster and McLean Counties; (2) Barren, Warren and Simpson Counties; (3) Ballard, Carlisle, Hickman and Fulton Counties; (4) a tier of counties extending southeast from Louisville across the southern part of the Bluegrass area.

Generally speaking, hog production in Kentucky is concentrated in the areas of heavy corn production. In the Bluegrass region, however, hogs show considerably more concentration than does the production of corn. For this reason the hog enterprise in this area takes the form of producing feeder pigs. During the period 1931 to 1935, 51 percent of the graded hogs weighed less than 160 pounds.

In eastern Kentucky because of small production of corn, hog production is also small. In this area the hogs are grown chiefly to supply meat for the farm family.

In the three areas, the Evansville, Western Purchase, and the South Central, the production of corn is larger and hogs are produced in much greater numbers than elsewhere in the State, also hogs are fed to slaughter weights. The hog-corn ratio for Union county, representing heavy-corn-production regions of the State followed closely the hog-corn ratio existing in Iowa, a typical corn-belt state, and was considerably higher than those which existed for the mountain regions or where insufficient corn is produced and the Bluegrass region where hog production was heavy in comparison to corn production. Thus in most of the State the hog-corn ratio is not favorable to the production of hogs.

In that part of Kentucky where the feeding ratio is unfavorable hog producers have had to depend upon other factors in making the hog project pay. In the Bluegrass Region many hogs are produced on pasture with only a small amount of concentrate, then sold as feeders. Also in this, as well as other parts of the State, producers follow the practice of selling the fall pig crop in April and May when there is a normal rise in hog prices. The bulk of the spring pig crop, which is ready for market in the winter, when the price of hogs is seasonally low, is used for the home meat and lard supply.

A definite relationship exists between prices paid for slaughter hogs at local markets in Central Kentucky, Bowling Green and

Henderson, and at the terminal markets of Cincinnati and Louisville. At Cincinnati, located farthest east and closest to the consuming centers, the prices were highest. Generally speaking, the farther away from these centers of consumption, the lower the prices. The differences in prices reflect market and transportation costs between the various points of sale.

The weight of hogs sold at various points in Kentucky was lighter than at important terminal markets, reflecting the relative high cost of feed in Kentucky. Prices received for certain weight hogs varied considerably in relation to prices paid for hogs of other weights during different years. When the general level of hog prices is falling, the demand for light-weight hogs for feeders and replacement also decreases and prices of these classes are low in relation to heavier hogs. The reverse is true when the general level of hog prices is on the up grade. The variation in the average price received for hogs of different weights can, therefore, be explained by the reaction of farmers to the price cycle of hogs.

Generally speaking, during the period studied, the highest prices were paid for hogs weighing between 200 and 220 pounds. To what weight it was most profitable to finish hogs in this section was not determined. The relatively small difference between the prices received for hogs of different weights, makes the availability and price of feeds the important factors in determining at what weight a farmer should sell his hogs.

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University of Kentucky

A MACHINE FOR CLEANING TOBACCO SEED

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A MACHINE FOR CLEANING TOBACCO SEED

L. S. O'BANNON and W. D. VALLEAU

In handling many strains and varieties of tobacco year after year, it is necessary that each lot of seed be cleaned separately without danger of mixture. It is also desirable that the light-weight seed be removed so that a weighed amount of seed will give the anticipated stand of plants in the bed. A combination of Nos. 20, 30, and 40 soil sieves with bottom pan makes a fairly effective cleaner for tobacco seed. The No. 20 catches the coarse material, the No. 30 the finer material, the No. 40 catches the seed and the pan catches the fine dust. It has the objection that after each lot of seed the sieves must be thoroly cleaned. The same objection holds for the manufactured seed cleaners equipped with shaking sieves. A cleaner for tobacco seed was introduced by the Bureau of Plant Industry, U. S. D. A., over 30 years ago.[1] This cleaner has proved valuable for cleaning small lots of seed and with modifications is still used in the seed laboratory of the Kentucky Experiment Station for the analysis of seed samples. It has the objections of being slower in operation than the machine to be described, of not having a uniform air velocity, and of not being suitable for continuous operation. It is, however, better adapted for seed analysis than the new machine in its present form.

To overcome these objections, the seed cleaner to be described in this bulletin was built. It has proved to be very satisfactory for the purpose for which it was designed; namely, cleaning small lots of seed, but it is also very satisfactory for cleaning large lots of tobacco seed. For this purpose, it is equipped with an automatic feed which, in turn, may be fed from a hopper of any desired size. The container for catching the cleaned seed may be of any desired size. The size of the container for catching the trash determines the amount of attention which must be given when large lots of seed are being cleaned.

1 Kentucky Agricultural Experiment Station Bulletin 129, 1907.

PREPARATION OF SEED FOR CLEANING

In breeding studies where a large number of varieties and strains of tobacco are grown year after year, it has been the practice to collect a few pods of each variety in the field and place them in

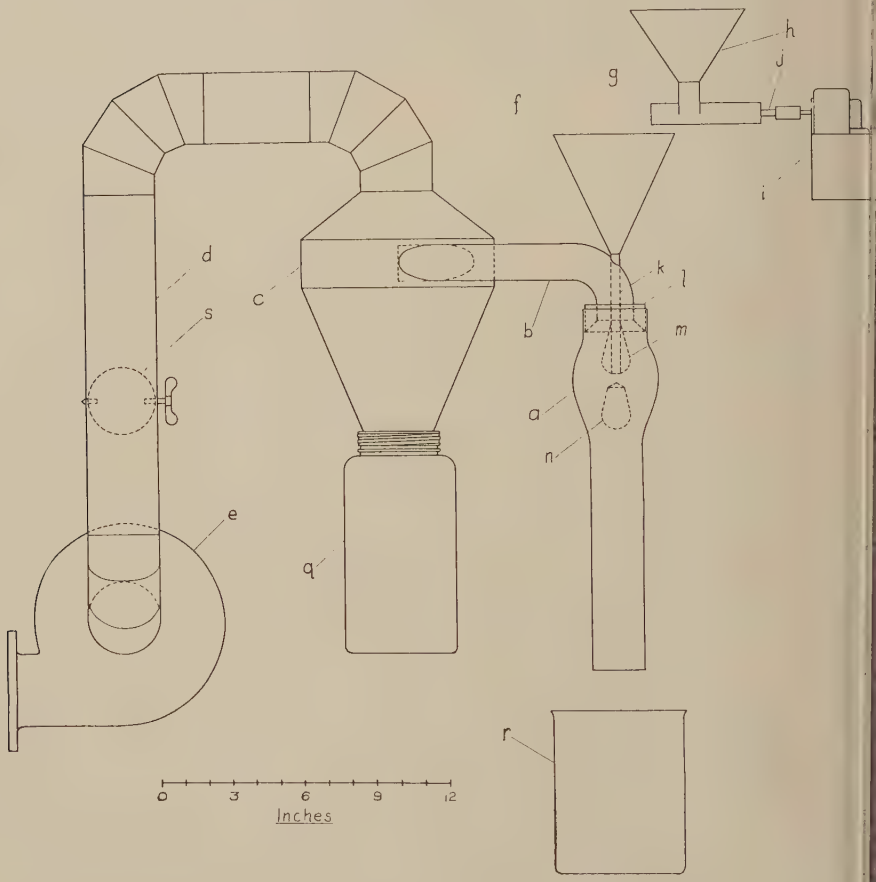


Fig. 1. Diagram of seed cleaner showing arrangement of parts.

a small envelope. If the pods are perfectly ripe, the seed may be poured directly into the envelope. If the pods are not dry, they are allowed to dry in the envelope. Before the seed is weighed out for the next sowing, it must be cleaned. The dry pods are poured on to

a piece of letter paper, crushed and the coarse material brushed off the paper with the fingers. The finer bits of pod material are then blown off and the remaining seed and trash are poured thru the seed cleaner. The seed cleaner is virtually self cleaning so that tapping the funnel dislodges any seeds which may have clung to the surface. The cleaned seed may then be poured back into the envelope. Larger lots of an ounce or two may be passed thru a No. 20 soil sieve, which is easily cleaned, and then run thru the cleaner.

In cleaning large lots of seed, the dry pods are crushed and poured thru a coarse sieve to remove the stems and larger bits of pod and then sieved thru a No. 20 sieve. They are then ready to be run thru the seed cleaner. If the larger bits of trash are not removed, they will clog the neck of the funnel and the heavier bits of dried tissue will pass down with the cleaned seed.

The seed cleaner has also proved to be very efficient in cleaning grass seeds such as bluegrass. It will not separate seeds of approximately equal weight, as tobacco seed and bluegrass, when mixed.

There appears to be no reason why the same principle could not be applied to a much larger seed cleaner for cleaning large volumes of light-weight seeds. It would be desirable, in a large separating chamber, to substitute a motor-driven distributing disk for the splash plate (See "o", Fig. 2) in order to give a more even distribution of seed thruout the larger chamber.

THE TOBACCO-SEED CLEANER

The essential parts of the seed cleaner are shown in Fig. 1. The seed to be cleaned is fed thru a funnel (f) into the upper end of a vertical glass tube (a). The tube has an enlargement near its upper end which constitutes the separating chamber. A current of air is drawn upward thru the separating chamber by means of the motor-driven fan (e). Heavy seeds fall against the current of air and are caught in a vessel (r). The vessel is located below the entrance of the tube at such a distance that it does not interfere with the flow of air. Light seeds and chaff are carried along with the air and are drawn out thru the top of the separating chamber.

The trash-laden exhaust air from the separating chamber flows

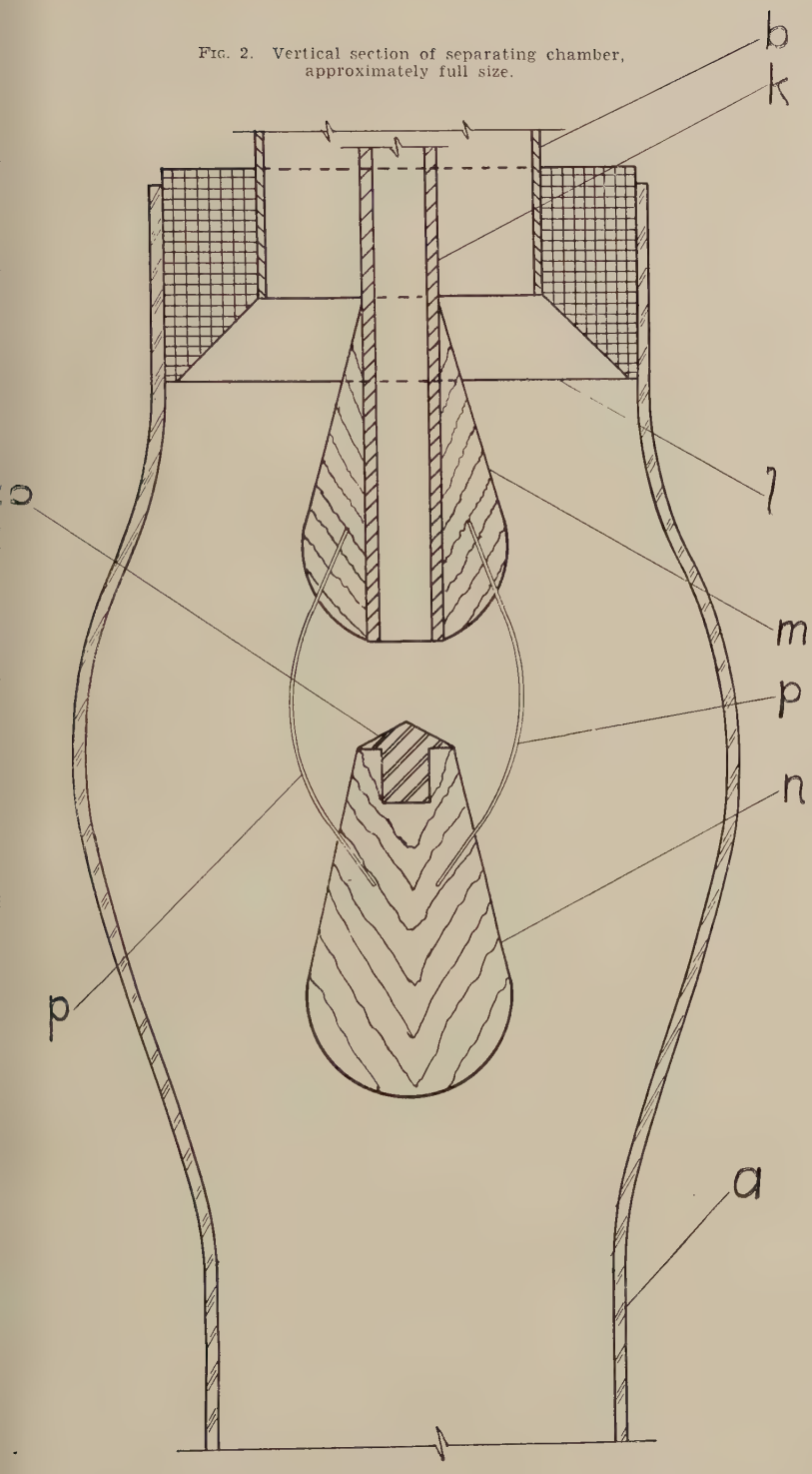
thru a brass tube (b) into a dust catcher (c) constructed on the principle of a cyclone separator. The air enters the dust catcher tangentially and is given a spiral motion. At the same time, the average velocity of the air is reduced because of the relatively large volume of the dust catcher. The trash is precipitated out of the main air stream by centrifugal force and gravity and is collected in a jar (q) fastened to the lower cone, or tail piece, of the dust catcher. The exhaust air from the dust catcher flows thru the duct (d) to the inlet of the fan (e). A damper (s) is provided for regulating the volume of air which, in turn, determines the upward velocity of the air in the separating chamber. A short piece of pipe connected to the fan outlet and arranged to direct the air into a large open box or can, has been found effective in catching traces of fine dust not separated out in the cyclone dust catcher.

To effect uniform cleaning, especially when large lots are to be cleaned, it is desirable that the uncleaned seed be introduced into the separating chamber at a constant rate. This is provided for by the feeder located above the funnel (f). The feeder consists of a motor-driven screw (j) which turns in the screw housing (g). The seed to be cleaned is placed in the hopper (h) which is connected to a hole in the top of the screw housing. The screw turns at constant speed and feeds the uncleaned seed at a uniform rate thru the funnel into the separating chamber.

For cleaning small quantities of seed in the laboratory, the practice has been to pour the seed slowly by hand directly into the funnel. For larger quantities, when it is desirable to use the feeder, the practice has been to put the seed in a paper bag, gathering the edges of the open end of the bag roughly into the shape of a funnel and then inverting it in the hopper. With containers of suitable capacity for collecting the clean seed and the trash, no attention is required after the cleaner is started until the operation is ended. A cleaner constructed to the specifications described in this bulletin has a capacity of approximately seven pounds of seed per hour.

Figure 2 is a full-size working drawing of the separating chamber. The letters used for designating the several parts are the same as those used in Fig. 1. The tube (k) which leads from the funnel to the separating chamber is a piece of 1/8-inch brass pipe.

Fig. 2. Vertical section of separating chamber, approximately full size.



(Standard 1/8-inch pipe has an internal diameter of 0.269 inches and an outside diameter of 0.405 inches). The seed falls thru the tube on to the splash plate (o) and scatters radially over the whole cross-sectional area of the separating chamber. The splash plate is mounted as shown on the small end of a pear-shaped piece of wood (n). In addition to holding the splash plate, the pear causes the

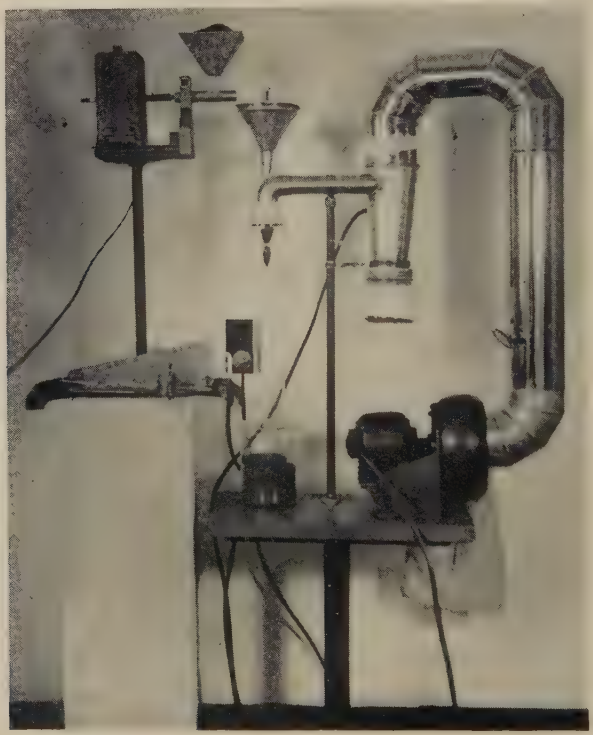


Fig. 3. Tobacco-seed cleaner and electrically-driven automatic feed. The diameter of the cyclone separator was too small; consequently a cloth bag was attached to the fan outlet to catch trash blown over. The machine was mounted on a table with 3 rollers so as to be easily moved about.

air to expand smoothly into the widest section of the chamber where the separation of light and heavy material takes place.

A coneshaped piece of wood with rounded base (m) is fitted over the end of the feed tube (k) as shown in the figure. This constricts the area of the separating chamber at this point and causes

a higher air velocity, so that light material once projected into this region is carried out with the exhaust air.

The lower pear-shaped piece of wood on which the splash plate is mounted is suspended from the upper piece of wood by means of two small wires (pp). The ends of the wires are thrust into holes bored with a short piece of the same wire used as a drill bit.

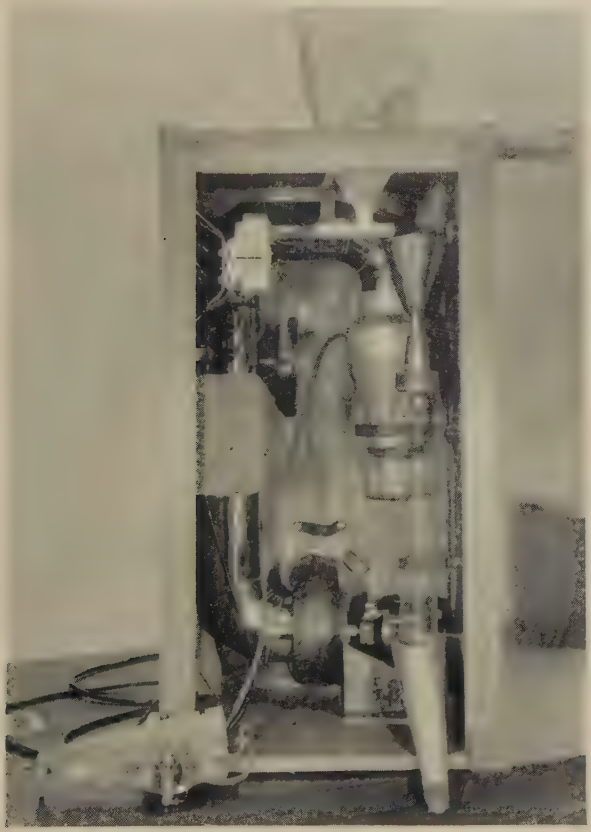


FIG. 4. The machine pictured is in commercial operation. It was built on the same principle as the first machine but all working parts are enclosed in a cabinet and securely attached to it. An electric light is mounted behind the shield at the left. Cleaned seed is discharged thru the funnel (lower right) into any convenient container. A 14-pound paper bag of uncleaned seed is inverted into the self-feeder hopper at the top. The damper in the stovepipe is manipulated by a handle which may be fastened at any opening by a wing nut to a semi-circular piece of metal mounted on wood on the upper left part of the back panel. A 2-quart trash jar can replace the pint jar shown.

The glass tube (a) is connected to the brass tube (b) by mean of a rubber bushing (l) of proper outside diameter and interna bore. The bottom face of the bushing is chamfered as shown t provide a gradual approach to the entrance of the brass tube.

FIG. 5. Another view of the machine shown in Fig. 4. The pipe at the lower left i to be fastened to the exhaust of the fan to convey any trash carried past the separato into a box or can. The cleaned-seed funnel is shown on the back panel where it i placed when the machine is not in operation. The sliding door at the right closes the machine completely when not in use.

SPECIFICATIONS

Detailed specifications of the various parts are given in the following list. The letters correspond to the labeling used in the figures.

(a) A standard lamp chimney, 2-⅝ inches at the base (upper end in the figure) and 15 inches long.

(b) A piece of 1-½-inch diameter plumbing brass. The straight length and elbow can be obtained in one piece. The tube is sol-

dered into a hole cut in the cylinder of the dust catcher, with the front side of the tube tangent to the surface of the cylinder.

(c) The dust catcher was built to specifications in a sheet-metal shop. The cylindrical part is 8 inches in diameter and 2 inches high. The upper cone tapers to the diameter of the duct (d). The lower cone tapers to a diameter determined by the size of the screw top of the jar (q). The over-all height of the dust catcher is about eleven inches. The material used was No. 26-gage galvanized iron.

(d) 3-inch diameter nickel-plated stovepipe. The arrangement shown requires one joint of pipe and three 90 degree elbows.

(e) Any small motor-driven centrifugal fan with a wheel having a diameter of approximately four inches and turning at standard motor speed of 1750 revolutions per minute. The fan shown in the photographs has an inlet diameter of four inches and an outlet diameter of three inches. The fan proposed in Figure 1 is of slightly different design. This fan has an inlet diameter suitable for 3-inch pipe. The motor speed is 2800 r. p. m. The fan may be mounted by bolting the flanged outlet to a suitable support.

(f) The funnel is formed of light-weight sheet metal and soldered to the brass pipe (k). Diameter at top, 5 inches; height, 5 inches. Care should be used in fitting the brass pipe to the funnel to avoid rough places or ledges that would catch seeds.

(g) 7/8-inch outside diameter thin brass tubing, 4-1/2 inches long (chandelier tubing from a local electrical shop).

(h) In plan view the hopper is square, each side being 4-3/4 inches long at the top. It is formed of light-weight galvanized iron. The bottom of the hopper is soldered to a short piece of 7/8-inch square brass tubing (chandelier tubing) which is soldered over a square opening in the top of the screw housing.

(i) A small 110 volt electric motor, about 500 watt capacity, with reducing gears to give a drive shaft speed of 28 r. p. m.

(j) A 3/4-inch wood-boring bit coupled to the motor shaft. The screw point and cutting edges of the bit are ground off. The end of the bit should be at least one full twist from the hopper outlet to prevent seed from pouring thru when the bit is not turning.

(k) A piece of 1/8-inch standard brass pipe about 5-1/2 inches long. The pipe is soldered in a hole drilled in the top of the elbow.

The hole is located on the line of the axis of the glass chimney. T pipe is carefully plumbed to bring its outlet in the center of t separating chamber. The upper end of the pipe is reamed approximately the same taper as the funnel.

(l) No. 13 rubber stopper.

(m) A wood turning. Maximum diamtter, 1-½ inches; lengt 1-¾ inches.

(n) A wood turning. Maximum diameter 1-½ inches; lengt 1-⅞ inches.

(o) An aluminum rivet with ¼-inch diameter shank. The riv was inserted in a hole drilled in the turning before the turning w removed from the lathe. The round head of the rivet was turne cone-shaped and polished.

(p) No. 24 gage nickel-alloy steel wire.

(q) A large-mouthed screw-top fruit jar. The screw-top rin is soldered to the tail piece of the cyclone separator.

(r) Any convenient receptacle.

(s) Damper improvised from heavy gage sheet metal and sui able fittings.

ADJUSTING AIR FLOW

The air flow thru the cleaner is regulated by the damper in th stovepipe. In the machine shown in Figs. 4 and 5 the damper i provided with a quadrant and locking nut. The most desirabl opening can be determined by inspection of the cleaned seed an trash. The damper may be locked in the position thus determine and the quadrant marked for future reference.

The manometer shown in the figures was used for obtainin relative indications of the air pressure while experimenting wit different velocities, but it is not an essential part of the machine.

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University of Kentucky

CALCIUM CONTENT OF THE YOLK OF FRESH AND STORAGE EGGS

BULLETIN NO. 382

Lexington, Ky.
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SUMMARY

Calcium was determined in the yolks of 193 fresh and 149 storage eggs. The eggs were produced under controlled conditions to test the effect of administration of cod liver oil to the hens, and of allowing them sunshine and bluegrass range. The results on fresh egg yolks indicate that any one of the vitamin D supplements tends to increase the calcium content of the egg yolk. Bluegrass range plus sunshine was no more effective than sunshine alone whether administered with or without cod liver oil. In storage eggs the calcium content of the yolk was higher than in fresh eggs.

Bulletin No. 382

CALCIUM CONTENT OF THE YOLK OF FRESH AND STORAGE EGGS

S. E. ERIKSON, R. E. BOYDEN, J. HOLMES MARTIN and W. M. INSKO, JR.

Some correlation has been shown between food intake of hens and the quality, as well as quantity, of eggs they produce but whether all the constituents of the egg respond to variations in dietary treatment of the hen has not been conclusively shown. As part of a study concerning the possibility of affecting the mineral content of the egg yolk, different vitamin D supplements were added to the rations of hens to determine what effect, if any, they might have on the calcium content of the egg yolk.

Altho there is probably a difference between mammals and fowl in calcium metabolism because of its utilization in egg shell formation, nevertheless, it was hoped that the study would give some further understanding of the relation between vitamin D and calcium in the organism. From experiments on other animals as well as on fowl, it has come to be generally accepted that the role of vitamin D is that of a regulatory action on the utilization of calcium and phosphorus for bone formation. A clear understanding is lacking, however, of the specific way in which such action takes place. Some evidence (Zucker and Matzner (1), Yoder (2), Redman (3)) exists that it promotes retention and normal absorption of calcium and phosphorus by preventing high alkalinity in the digestive tract. According to McGowan (4) the most important single factor controlling the absorption of calcium and phosphorus appears to be gastric acidity. He says also that phosphorus absorption depends on the calcium concentration of the diet because excess calcium carbonate in the diet, after neutralizing HCl of the gastric juice, precipitates the phosphorus as $Ca_3(PO_4)_2$. The result is that less phosphorus is absorbed and the blood phosphorus is lower with its sequelae of rickets. If, however, an abundance of vitamin D is present, rickets does not result.

However, this is probably not proof that vitamin D acts specifically on the acidity of the digestive tract. Taylor and Weld (5) advance the theory that its influence is on the deposition of calcium

and phosphorus in the bone rather than directly on the absorption of these elements. A relationship between vitamin D and the parathyroids in connection with calcium metabolism is brought out in important evidence by Morgan and Garrison (6) and Morgan and Field (7).

In hens, the action of vitamin D on calcium metabolism obviously extends to other tissues than bone. In the laying hen calcium metabolism is increased because of the large amount used by the bird in egg shell formation. During egg production the calcium content of the blood of the hen may rise to 23.5 mg. per 100 ml.* as compared to a constant level maintained by cockerels of 10-11 mg. per 100 ml. of serum (8). That the calcium mobilization is related to vitamin D appears in the fact that its absence results in diminished egg size (9), diminished egg production and thin shells (10). Buckner, Martin and Peter (11) consider that the percentage content of the egg tends to remain constant and that response of the hen to a deficiency in ration is diminished egg production. Nevertheless, their figures show a consistent increase in percentage of calcium in the egg contents parallel to a calcium supplement in the ration of the hen. This indicates a metabolic effect that may help explain some of the problems of mineral needs, even tho the differences that occurred may not be of a magnitude to interest poultrymen.

Since all the processes of metabolism are so closely interrelated, the factors which affect the level of serum calcium may also affect the functioning of all tissues. Therefore, it seems possible that the administration of vitamin D to laying hens may be reflected in the content of calcium in the egg. An investigation of the problem has been carried out as part of a larger study on the nutritive value of eggs.†

The procedure for the experiment has been reported in a previous paper (12). The variation in pen treatment is repeated only in order to keep in mind the factors of vitamin D administration that concern calcium metabolism. It suffices to say, therefore, that the hens were kept in three pairs of pens, as follows:

First pair. Confined to house, no direct sunshine, only sunlight thru common window glass.

Pen 1—No cod liver oil. Pen 2—2% cod liver oil.

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* ml. is an abbreviation for milliliter, the one-thousandth part of a liter.
† Ky. Agr. Exp. Sta. Bull. Nos. 335, 337, 342 and 378.

Second pair. Confined to house and wire-screened, wire-floored sun porch.

Pen 3—No cod liver oil. Pen 4—2% cod liver oil.

Third pair. Allowed range of bluegrass yard.

Pen 5—No cod liver oil. Pen 6—2% cod liver oil.

The mash for all the pens had a ratio of calcium to phosphorus of 1.73:1. The percentage of calcium was 2.15 and that of phosphorus 1.24. In addition, coarsely ground limestone, approximately 99 percent $CaCO_3$ was available at all times. Norris and co-workers (13) state that 0.75 percent of phosphorus and 1.80 percent of calcium in the ration of pullets give optimum results as indicated by egg produciton, egg shell strength, and calcium and phosphorus in the blood. It is probably safe to assume, therefore, that in the experiment, reported here, calcium and phosphorus in the diet are available at an optimum level and that whatever variations occur are due to the vitamin D supplement.

METHODS

Eggs from 6 hens in each pen were collected daily during 5 periods of 10 days each and analyses made for calcium in the yolks. Eggs from the same 6 hens were collected during a sixth period of 30 days and placed in cold storage at the end of each day. After being stored twelve months the calcium in the yolk was determined.

The eggs were weighed, then broken against the edge of a beaker and the white separated from the yolk. A portion of the yolk was placed in a porcelain crucible and dried slowly, beginning at a temperature of 40°C. and increasing gradually to 70°C. It was then burned in a muffle furnace to a white ash. The ash was dissolved in about 40 ml. of dilute hydrochloric acid, evaporated to dryness, taken up in dilute hydrochloric acid, transferred to a 100 ml. volumetric flask and diluted to volume. Aliquot portions of 15-20 ml. were taken for duplicate determinations of calcium. Slight modifications were made in the Clark and Collip (14) method for calcium, which is based on McCrudden's (15) method.

RESULTS

Protocols of the detailed data are filed at the Kentucky Agricultural Experiment Station Library. Individual analyses were made of the yolks of 193 fresh and 149 storage eggs. Mean values per hen and per pen for fresh and storage eggs are found in Tables 1 to 4.

The Yolk of Fresh Eggs

In the statistical analysis of the data, the difference between two pens is considered significant and real if the difference of the means divided by the probable error of the difference of the means, i. e. $\frac{D}{P.E.\ diff.}$ gives a quotient of 3 or more. If it is less than three it is not held to be significant.

The difference of average values is brought out in table 2. The difference between pens 1 and 2 is highly significant and indicates that the cod liver oil had a marked effect on the deposition of calcium in the egg yolk. The difference between 1 and 3 is just as significant, which indicates that sunshine had an effect similar to that of cod liver oil on yolk calcium. A combination of sunshine and bluegrass range in pen 5 gave a similar difference as did also a combination of sunshine, bluegrass range and cod liver oil in pen 6. The differences are small but, nevertheless, significant. The influence of cod liver oil added to the ration of the pens that were already getting either sunshine or sunshine plus blugrass is so small as not to be significant. It appears that the effectiveness of each supplement for the utilization of calcium is about the same. Table 1 shows that the differences between hens are as great as the differences between pens but that values are lowest in pen 1. The lowest value for calcium was found in pen 1, which did not get a vitamin D supplement.

Hart and others (16) analyzed the yolks of eggs produced by hens irradiated and non-irradiated. Their average value expressed as calcium oxide in the yolk of eggs from the non-irradiated hens was 0.368 percent of dried yolk and in the yolk of eggs from the irradiated hens 0.431 percent. Irradiation of the hens by a quartz mercury vapor lamp seems, therefore, to have about the same effect as sunshine or cod liver oil administered to the hens in this investigation. The comparable figures in table 2 in this paper expressed as calcium oxide of the wet weight of the yolk, are 0.175 percent for pen 1 (without either sunshine or cod liver oil), 0.216 percent for pen 2 (without sunshine but given cod liver oil) and 0.222 percent for pen 3 (given sunshine but not cod liver oil). Lacking statistical analysis of the figures of Hart and others (16), it is not possible to compare the significance of their figures with the ones in this paper. Payne and Hughes (17) found that the mineral composition of the egg is altered when the hens develop rachitic

condition resulting from the absence of ultra-violet rays. Their values for the calcium of the yolk are somewhat higher than the ones reported here but the trend is the same. Their figures are 0.212 percent for hens inside away from the light, 0.242 percent for hens irradiated and 0.264 percent for hens allowed direct sunshine.

Insko and Lyons (18), using the same hen treatment as in this investigation, studied the effect on embryo mortality of the different vitamin D supplements. They found a much higher mortality in eggs produced by hens confined without any vitamin D supplement. The high mortality, however, may have been due to a combination of factors and not to the lower calcium value alone. For instance, the inorganic phosphorus of egg yolk produced under the same conditions as the above (19), was smaller in amount in the eggs produced by hens kept confined without vitamin D supplement. Lack of vitamin D in the egg itself may also have had an influence.

Statistical treatment of the figures for calcium and phosphorus fails to show any correlation between calcium and inorganic phosphorus, calcium and total acid soluble phosphorus or calcium and total phosphorus.*

The Yolk of Storage Eggs

Tables 3 and 4 correspond to the tables on fresh eggs except that table 3 does not give the percentage of CaO in the ash. The average calcium content of egg yolks from each pen was higher when stored than when fresh except in pen 3. The loss of water that occurs during storage probably does not account entirely for the differences. There may be a slight transfer of calcium from the shell to the yolk. The differences in values between pens give no indication that the vitamin supplements affected the changes that took place. Table 4 brings out the fact that in storage eggs consisently higher values of CaO were found in the pens getting a vitamin D supplement, but the differences are not so great as in fresh eggs. Statistical analysis does not permit that they even be considered significant.

During the twelve months that the eggs were stored the condition of the storage plant became such that the eggs had to be moved to another plant. Some of the eggs showed distinct deterioration so that it was impossible to get the yolk out intact and the data, therefore, are incomplete.

* Protocols in Agricultural Experiment Station Library.

Table 1. Average calcium oxide in the yolk of fresh eggs from each hen.

Pen No.	Treatment of the hens	Hen No.	Grams per yolk	Percent in yolk	Percent in ash
Confined, Sunshine Thru Ordinary Glass					
1.	No cod liver oil	386	.0263	.169	11.5
		387	.0294	.170	10.2
		391	.0286	.172	11.6
		392	——	——	——
		395	——	——	——
		402	.0297	.200	12.4
2.	With cod liver oil	410	.0356	.213	13.7
		411	.0348	.236	13.4
		421	——	——	——
		426	.0326	.213	13.2
		427	.0323	.207	13.1
		428	.0364	.224	14.2
Confined, Direct Sunshine					
3.	No cod liver oil	441	.0360	.214	13.4
		448	.0324	.201	13.0
		453	.0414	.250	14.7
		456	.0362	.209	13.1
		457	.0420	.234	13.9
		461	.0393	.247	15.4
4.	With cod liver oil	466	.0372	.200	13.4
		467	.0340	.206	12.9
		476	——	——	——
		482	——	——	——
		486	.0357	.242	15.3
		488	.0348	.213	13.1
Bluegrass Range, Sunshine					
5.	No cod liver oil	501	.0324	.206	12.4
		502	.0329	.204	12.6
		508	.0334	.232	14.5
		514	.0370	.208	12.9
		519	.0371	.243	15.3
		521	.0410	.227	13.7
6.	With cod liver oil	530	.0371	.267	16.4
		541	.0338	.212	13.2
		544	.0333	.211	13.9
		549	.0279	.194	12.3
		550	.0413	.268	15.9
		554	.0367	.212	13.3

Table 2. The difference of the means of calcium oxide per 100 grams of yolk of fresh eggs.

Pen No.	Treatment of the hens	No. Obs.	Means*	Difference	Standard deviation	D / P.E. diff.
			grams	grams		
Confined, Sunshine Thru Ordinary Glass						
1.	No cod liver oil	15	.175±.0040		.0223±.0028	
2.	With cod liver oil	27	.216±.0025	.041±.0047	.0191±.0018	8.7
Confined, Direct Sunshine						
3.	No cod liver oil	30	.222±.0035		.0283±.0025	
4.	With cod liver oil	27	.210±.0029	.012±.0046	.0218±.0020	2.6†
Bluegrass Range, Sunshine						
5.	No cod liver oil	46	.221±.0028		.0283±.0020	
6.	With cod liver oil	48	.223±.0037	.002±.0047	.0380±.0026	0.4
No Cod Liver Oil						
1.	Confined, sunshine thru ordinary glass	15	.175±.0040		.0223±.0028	
3.	Confined, direct sunshine	30	.222±.0035	.047±.0054	.0283±.0025	8.7
1.	Confined, sunshine thru ordinary glass	15	.175±.0040		.0223±.0028	
5	Bluegrass range, sunshine	46	.221±.0028	.046±.0049	.0283±.0020	9.4
3.	Confined, direct sunshine	30	.222±.0035		.0283±.0025	
5.	Bluegrass range, sunshine	46	.221±.0028	.001±.0046	.0283±.0020	0.2†
With Cod Liver Oil						
2.	Confined, sunshine thru ordinary glass	27	.216±.0025		.0191±.0018	
4.	Confined, direct sunshine	27	.210±.0029	.006±.0037	.0218±.0020	1.6†
2.	Confined, sunshine thru ordinary glass	27	.216±.0025		.0191±.0018	
6.	Bluegrass range, sunshine	48	.223±.0037	.007±.0045	.0380±.0026	1.6
4.	Confined, direct sunshine	27	.210±.0029		.0218±.0020	
6.	Bluegrass range, sunshine	48	.223±.0037	.013±.0047	.0380±.0026	2.8
Extreme Conditions						
1.	No vitamin D supplement, no cod liver oil, confined	15	.175±.0040		.0223±.0028	
6.	With vitamin D supplements, i.e. cod liver oil, sunshine and bluegrass range	48	.223±.0037	.048±.0037	.0380±.0026	12.9

* Obtained by averaging the values for all yolks of each pen. † The additional supplement did not increase the calcium content of the yolk.

Table 3. Average calcium oxide in the yolk of storage eggs from each hen.

Pen No.	Treatment of the hens	Hen No.	Grams per yolk	Percent in yolk
Confined, Sunshine Thru Ordinary Glass				
1.	No cod liver oil	386	.0218*	.134*
		387	——	——
		391	.0434	.254
		392	.0504*	.185*
		395	——	——
		402	.0301*	.202*
2.	With cod liver oil	410	.0412	.258
		411	.0325	.184
		421	.0387	.219
		426	.0349	.207
		427	.0345	.254
		428	.0401	.233
Confined, Direct Sunshine				
3.	No cod liver oil	441	.0382	.217
		448	——	.175
		453	——	——
		456	.0388	.197
		457	.0466	.228
		461	——	——
4.	With cod liver oil	466	.0420	.200
		467	.0333	.216
		476	——	——
		482	.0445	.234
		486	.0508*	.299*
		488	.0416	.248
Bluegrass Range, Sunshine				
5.	No cod liver oil	501	.0327	.242
		502	.0376	.238
		508	.0374	.248
		514	.0543	.265
		519	.0412	.240
		521	.0469	.244
6.	With cod liver oil	530	.0411*	.300*
		541	.0406	.245
		544	.0396	.238
		549	.0455	.259
		550	.0450	.288
		554	.0398	.221

* Single determination.

Table 4. The difference of the means of calcium oxide per 100 grams of yolk of storage eggs.

Pen No.	Treatment of the hens	No. Obs.	Means*	Difference	Standard deviation	D / P.E. diff.
			grams	grams		
Confined, Sunshine Thru Ordinary Glass						
1.	No cod liver oil	7	.220±.0135		.0489±.0095	
2.	With cod liver oil	20	.231±.0096	.011±.0165	.0618±.0068	.7
Confined, Direct Sunshine						
3.	No cod liver oil	23	.209±.0046		.0319±.0032	
4.	With cod liver oil	24	.241±.0112	.032±.0121	.0799±.0079	2.6
Bluegrass Range, Sunshine						
5.	No cod liver oil	44	.245±.0048		.0462±.0034	
6.	With cod liver oil	31	.250±.0065	.005±.0081	.0527±.0046	.6
No Cod Liver Oil						
1.	Confined, sunshine thru ordinary glass	7	.220±.0135		.0489±.0095	
3.	Confined, direct sunshine	23	.209±.0046	.011±.0142	.0319±.0032	.8†
1.	Confined, sunshine thru ordinary glass	7	.220±.0135		.0489±.0095	
5.	Bluegrass range, sunshine	44	.245±.0048	.025±.0143	.0462±.0034	1.7
3.	Confined, direct sunshine	23	.209±.0046		.0319±.0032	
5.	Bluegrass range, sunshine	44	.245±.0048	.036±0066	.0462±.0034	5.5
With Cod Liver Oil						
2.	Confined, sunshine thru ordinary glass	20	.231±.0096		.0618±.0068	
4.	Confined, direct sunshine	24	.241±.0112	.010±.0147	.0799±.0079	.7
2.	Confined, sunshine thru ordinary glass	20	.231±.0096		.0618±.0068	
6.	Bluegrass range, sunshine	31	.250±.0065	.019±.0115	.0527±.0046	1.7
4.	Confined, direct sunshine	24	.241±.0112		.0799±.0079	
6.	Bluegrass range, sunshine	31	.250±.0065	.009±.0130	.0527±.0046	.7
Extreme Conditions						
1.	No vitamin D supplement, no cod liver oil, confined	7	.220±.0135		.0489±.0095	
6.	With vitamin D supplements, i.e. cod liver oil, sunshine and bluegrass range	31	.250±.0065	.030±.0150	.0527±.0046	2.0

* Obtained by averaging the values for all yolks of each pen. † See footnote to table 2.

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PRODUCTION REQUIREMENTS FOR CROPS AND LIVESTOCK IN THE BLUEGRASS REGION OF KENTUCKY

BULLETIN NO. 383

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Bulletin No. 383

PRODUCTION REQUIREMENTS FOR CROPS AND LIVESTOCK IN THE BLUEGRASS REGION OF KENTUCKY

W. L. ROUSE and GEO. B. BYERS*

The purpose of this study was to determine the physical requirements and production obtained for each farm enterprise. In addition, the costs and returns were ascertained for each crop and livestock enterprise and for the farm as a unit. The following pages show the amount of labor, feed, fertilizer and other requirements necessary for the production of crops and livestock.

The area studied was confined to farms in the inner bluegrass region of Central Kentucky in Fayette, Bourbon, Clark, Woodford, Jessamine, Scott and Harrison Counties. The periods covered extended from 1921 to 1929 and 1932 to 1936. Most of the livestock records covered the latter period. During the period from 1921 to 1929 the complete-cost method was used. Detailed records were kept by the farmers and a route man visited the farms every two to four weeks. The data for the period, 1932 to 1936, were compiled from the livestock-enterprise records. Twenty-seven farmers kept these complete cost records, covering one to nine years. Besides the enterprise records, livestock data covering one to thirteen years were obtained from fifty-seven farmers.

The Bluegrass Region is one of the most productive agricultural sections of Kentucky. It is characterized by the large amount of land devoted to bluegrass pasture. Diversified farming is practiced on most farms, but the type of production differs in different localities. Livestock and white Burley tobacco are the principal sources of income. The natural fertility of the region is due in large part to the high content of calcium phosphate in the soil, derived from the rocks, mainly limestone, from which the soil was formed. The

* The authors wish to acknowledge the valuable assistance received from Mr. W. G. Finn in supervision of the tabulation of the field data and for his assistance in writing several of the sections. They wish to thank Mr. W. R. Gabbert, Mr. J. C. Melvin, Mr. E. L. Langsford, Mr. Thomas Baird, Mr. A. B. Poundstone, and Mr. D. E. Bayless for their assistance as field men on the study.

soil of the central section, derived mainly from the Lexington (Trenton) limestone, is especially rich in calcium and phosphorus and the topography is favorable for all kinds of field work. The soil in the other sections, derived from later geological formations, tho very fertile, is, on the whole, less productive and the country is more rolling and broken. It is true that some of the soils, even in the inner area, are not very well supplied with phosphate, and on these the major cause of low crop yield may be insufficient available plant food. However, the entire territory produces good bluegrass and possesses considerable uniformity in the methods of land utilization.

The climate of the region is well suited to the production of many crops. The growing season for most plants averages approximately six months. Normally, the last killing frost in the spring occurs about the middle of April and the first in the fall, in the latter part of October. Winters are fairly open and the hardy grazing plants usually make some growth. However, sudden changes in temperature are common and the soil freezes and thaws many times each winter. This makes erosion a serious factor on land not protected by plant growth, and is one of the reasons why cover crops are used so generally.

The normal yearly precipitation for this region is 42 inches, sufficient to produce satisfactory yields. In most years this amount is fairly evenly divided between summer and winter but its distribution may be such as to limit the production of crops, especially those making their principal growth during the summer. For example, in a study of the yield of corn on the Kentucky Agricultural Experiment Station farm at Lexington, it was found that the amount and frequency of rainfall during June, July and August had more influence upon yield than any other single factor, including the application of fertilizers.[1]

Soil, topography and climate all have had great influence upon the character and condition of central Kentucky agriculture. In 1929 more than half of the total farm land was in grass, and four-fifths of this was *considered plowable*.[2] In the inner counties the

1 Kentucky Agricultural Experiment Station Bulletin No. 272, pages 294-297.
2 United States Census.

proportion of farm land in grass, and the proportion tillable are even larger, in spite of the fact that the land produces higher yields of harvested crops and had a higher sale value. A comparison of this region with adjoining states brings out strikingly the importance of bluegrass in land utilization (see Table 1). In Indiana and Illinois, only about 15 to 20 percent of the tillable land is used for pasture, whereas in central Kentucky, pasture occupies 60 percent of the tillable land.[3] Tennessee, Missouri and Virginia each makes extensive use of pasture altho neither state has more than 37 percent of its tillable land in pasture. West Virginia uses more tillable land for grazing than any other state, but the portion of plowable land thus utilized is only 47 percent as compared with 60 percent for central Kentucky. In no other part of the nation is such valuable land devoted so largely to grasses.

Table 1. Importance of pasture in the utilization of tillable land in Kentucky and adjoining states, 1929.[1]

Region	Total farm land	Amount of land tillable	Crop land harvested	Pasture land plowable	Plowable pasture per acre of crops harvested	Percent tillable land in pasture
	1000 A	1000 A	1000 A	1000 A	Acres	Percent
Bluegrass Region	4,881	3,567	1,270	2,171	1.7	61
Inner	862	736	246	481	2.0	65
Intermediate	1,286	1,032	353	650	1.8	63
Outer	2,734	1,799	671	1,040	1.5	58
Other Kentucky	15,046	8,795	4,061	3,223	.8	37
Total Kentucky	19,927	2,322	5,331	5,395	1.0	44
West Virginia	8,802	3,625	1,655	1,718	1.0	47
Virginia	16,727	7,984	3,975	2,925	.7	37
Missouri	33,743	22,664	13,176	7,018	.5	31
Tennessee	18,003	10,417	6,106	2,751	.5	26
Ohio	21,514	15,032	10,116	3,763	.4	25
Indiana	19,689	14,532	10,214	2,810	.3	19
Illinois	30,695	25,232	18,958	4,092	.2	16

1 Adapted from U. S. Census for 1929. Figures for 1924 show the same approximate relationships as those indicated here.

Bluegrass fills a very important place in most systems of farming in this region. It is excellent for pasturage and constitutes the major part of the feed of much of the livestock during the year. It helps maintain soil productivity; hence larger yields are pro-

3 Data from U. S. Census. "Pasture" refers to all forms of plant growth used for grazing. In central Kentucky it includes grass fields stripped for seed as well as those used exclusively for pasturage.

duced from crops which follow it. The sod improves the physical condition of the soil and helps to prepare it for the production of high-quality tobacco. In addition to the contributions made by bluegrass to other farm enterprises, it produces also a valuable seed crop. In the central counties of the region often as much as 75,000 to 100,000 acres are stripped for seed, yielding on the average about 400,000 bushels annually. This amount, in terms of money income, returns approximately one-half million dollars to farmers in these counties.[4]

The many uses that can be made of bluegrass are responsible for the large part that it plays in the utilization of farm land. Pasture production alone probably would not justify its growth upon such high-priced land; neither would its soil-maintaining nor its land-conditioning properties alone. Since, however, these benefits contribute toward each other so directly and work together so well, bluegrass usually is included in the systems of farming in central Kentucky.

The amount of farm land classed as tillable has decreased since 1910, especially in the outlying portions of the region (see Figure 1). This is because economic conditions do not justify the cultivation of some land formerly cultivated, and because improvident methods of use have rendered some otherwise good land unfit for tillage. However, it should be borne in mind that the distinction between tillable and untillable land is relative. With higher prices for agricultural products it is quite likely that some land now regarded as untillable would be considered suitable for cultivation.

Crops that are harvested occupy about one-fourth the farm land in this region. During the past few decades important changes have been made in the acreages of the different crops. Corn was produced more widely than other crops but in recent years its acreage has declined, particularly since 1920. Hay production, on the other hand, has increased. This has taken place gradually and the increase has varied in different sections, being greatest on the less fertile land. Wheat which at one time probably was the most important cash crop, especially in the central part of the region,

4 See Kentucky Experiment Station Bulletin No. 247, page 48, also Missouri Experiment Station Circular No. 155, page 7.

has had a very marked decline, and in many places has practically disappeared. The production of other small grains for harvest also has become unimportant. However, the fall seeding of rye and wheat upon cultivated land for cover crops and pasture, is a very

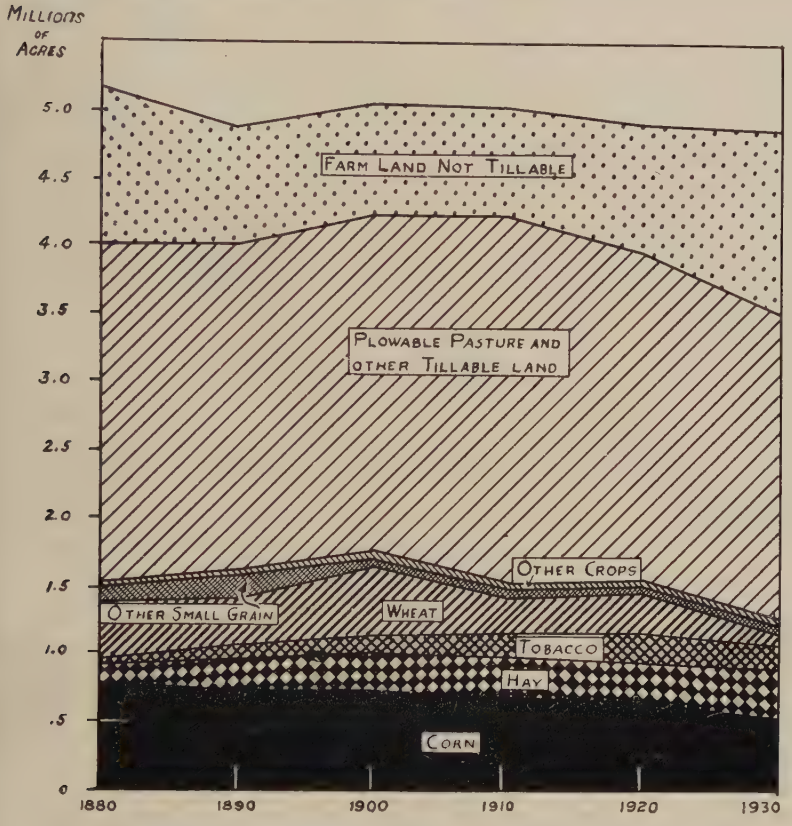


FIGURE 1. Land use in the Bluegrass Region (1880 to 1930).

common practice. Formerly hemp was grown extensively in some of the counties, but it has not been an important crop for more than twenty years. White Burley tobacco was not introduced into parts of the region until as late as 1880 and 1890. However, it soon met with favor and spread rapidly into all sections. The central and southern counties were the last to begin producing tobacco of this

type but they were very quick to adopt it and by 1900 or shortly thereafter, most of the systems of farming included some Burley.

The relative importance of these crops in the different parts of the Bluegrass has varied considerably and what has been noted with respect to the region as a whole may not be true in each of its subdivisions[5] (see Table 2). This was due largely to the natural factors of soil fertility and topography but it is partly the result of other influences also. Crop yields in the inner counties are higher than in the other counties but the margin of advantage is not the same for all crops (see Table 3). Wheat, for example, yielded nearly one-fourth more per acre in the inner than in the intermediate or outer counties, hence more of it has been grown in the inner counties. Yield of hay, on the other hand, was about as large in the outer counties as in the inner, with the result that this crop is relatively more important in the outer counties.

Tobacco and corn compete with each other for the use of land for cultivating, especially that which is very productive. Farmers often consider it more profitable to buy their corn than to raise it upon land capable of producing high-quality tobacco. Hence, the decrease in corn acreage has been greatest in counties where tobacco production was largest.

A large part of the cultivated crops are produced by tenants and hired labor. This is especially true in the central counties but it applies to much of the outlying territory as well. Tenants produce two-thirds or more of all the tobacco, hence the development of tobacco production has greatly influenced the amount and character of tenancy. In days before this crop had become important only twenty-five percent of the farms were operated by tenants, whereas today forty percent of the farms are operated by tenants. In the heaviest tobacco-producing counties the percentage of tenancy exceeds fifty.[6] While tenancy has thus increased, the form of rental has been changed greatly and cash tenancy has largely

5 The subdivisions here used are those made by W. D. Nicholls in Kentucky Experiment Station Bulletin No. 303, viz: *Inner bluegrass counties*, Bourbon, Clark, Fayette, Jessamine, Scott, Woodford; *Intermediate bluegrass counties*, Boyle, Franklin, Garrard, Harrison, Madison, Mercer, Montgomery, Shelby; *Outer bluegrass counties*, Anderson, Bath, Bracken, Carroll, Fleming, Gallatin, Grant, Henry, Lincoln, Marion, Mason, Nelson, Nicholas, Owen, Pendleton, Robertson, Spencer, Trimble, Washington.

6 See Kentucky Experiment Station Bulletin No. 303, pages 136-141.

given way to share tenancy. The number of share tenants in 1930 was more than three and one-half times that in 1880 but the number of cash tenants was less than one-third as great. Thus, while cash tenants operated over forty percent of the rented farms in 1880 they operated less than six percent of them in 1930.

Farms in this region are relatively larger than in most of the

Table 2. Percent of tillable land occupied by selected crops in different parts of the Bluegrass Region, by census periods, 1880 to 1930, inclusive.

	1880	1890	1900	1910	1920	1925	1930
All crops:							
Inner	35.0	44.1	51.1	40.8	42.8	32.3	34.3
Intermediate	37.8	40.1	41.2	37.0	40.0	33.3	34.4
Outer	40.5	39.3	39.2	34.0	37.5	33.7	37.7
Corn:							
Inner	15.5	16.3	18.4	16.5	16.1	14.8	11.5
Intermediate	20.0	18.6	17.6	17.4	17.9	16.4	15.3
Outer	21.6	18.6	17.4	16.0	16.0	15.8	16.4
Tobacco:							
Inner	*	2.2	3.9	4.3	7.3	6.1	6.7
Intermediate	.4	1.7	2.1	3.5	5.2	4.3	5.2
Outer	2.1	3.0	3.4	4.5	5.2	4.4	5.2
Hay:							
Inner	2.4	6.8	7.6	6.7	6.0	6.1	8.3
Intermediate	3.2	5.7	6.8	7.2	6.8	7.7	8.9
Outer	3.4	5.6	6.2	7.4	8.4	8.9	11.8
Wheat:							
Inner	11.8	11.5	17.0	10.6	10.9	1.5	3.8
Intermediate	10.5	9.2	12.5	6.2	6.9	1.5	2.7
Outer	9.9	6.5	8.9	3.4	5.7	1.1	1.7
Oats:							
Inner	1.6	3.1	.9	.8	.6	2.3	.6
Intermediate	2.0	3.4	1.0	.8	1.1	2.0	.9
Outer	2.1	4.1	1.5	1.3	1.4	2.2	1.5
Rye:							
Inner	.7	.6	.3	.4	.3	.5	.9
Intermediate	1.7	.9	.3	.6	.6	.3	.4
Outer	.1	.1	*	*	*	*	.2
Barley:							
Inner	1.6	.5	*	.5	.4	.2	*
Intermediate	.1	*	*	*	.1	.1	*
Outer	—	—	—	—	*	*	*
Hemp:							
Inner	.4	2.3	1.4	.5	*	*	*
Intermediate	.1	.5	.3	.2	*	*	*
Outer	*	*	*	*	*	*	*

* Not reported or less than one-tenth of one percent.

Table 3. Yields per acre of corn, tobacco, wheat and hay in different parts of the bluegrass region, by Census periods, 1880 to 1930, inclusive.

Year	Corn			Tobacco[1]			Wheat			Hay		
	Inner	Inter-mediate	Outer	Inner	Inter-mediate	Outer	Inner	Inter-mediate	Outer	Inner	Inter-mediate	Outer
	bus.	bus.	bus.	lbs.	lbs.	lbs.	bus.	bus.	bus.	tons	tons	tons
1880	37	33	30	717[2]	758[2]	878	17	12	12	.8	.7	.9
1890	41	36	33	1135	963	894	18	14	13	1.1	1.0	1.0
1900	28	28	26	1100	962	872	15	12	11	1.1	1.0	1.0
1910	40	35	33	1133	1008	955	15	12	11	1.1	1.1	1.1
1920	34	30	24	981	850	715	15	14	13	1.2	1.1	1.0
1925	37	33	29	930	860	840	14	12	11	1.2	1.0	1.0
1930	32	29	26	980	811	783	14	12	12	1.2	1.2	1.2

1 Apparent decreases in yield since 1910 were due largely to changes in market demand. Increased use of Burley for cigarette manufacture has popularized the lighter-colored, lower-yielding strains. 2 At this date Burley was just being introduced. These figures are from small acreages probably by inexperienced growers.

other parts of the state. In the central part, especially, a good deal of the land was in large estates, but many of these have been subdivided and are now operated in smaller, independent units. However, numerous large farms still are maintained, some for general farming, others as breeding establishments and show places. Nearly half the farm land is owned in tracts larger than 260 acres, and about 25 percent of it in tracts larger than 500 acres.[7] In the intermediate and outer counties only about 20 to 25 percent of the land is in holdings larger than 260 acres, while less than 10 percent is in units which exceed 500 acres.

The combination of crops and livestock on farms in the Bluegrass varies considerably. Tobacco production normally is combined with feed production, hence, raising livestock to utilize these feeds is an important part of the farm business. On the larger farms most combinations include some roughage-consuming livestock, such as beef cattle and sheep, as well as varying numbers of hogs. Livestock on the smaller farms often are principally dairy cattle and poultry but many of the smaller farms have other classes of animals. The number of livestock per 1000 acres of farm land is shown in Figure 2.

The number of sheep decreased from 1880 to 1900, increased from 1900 to 1910, decreased again after 1910, and made a marked increase from 1920 to 1930. Cows and heifers two years old or more, kept mainly for milk, increased slightly from 1880 to 1930. While beef cattle and poultry fluctuated considerably from one census period to another, they showed a small increase from 1880 to 1930. The number of hogs changed considerably and decreased slightly since 1880. Horses and mules increased from 1880 to 1890 after which they decreased with a marked falling off from 1920 to 1930.

Changes in the number of sheep followed fairly closely the change in pasture area in the Inner Bluegrass region. Sheep are a means of utilizing bluegrass pasture and some unmarketable roughage.

Beef cattle use considerable pasture area and unmarketable

7 See Kentucky Experiment Station Bulletin No. 259, page 65.

roughage. Dairy cattle use large areas of pasture, some unmarketable roughage and a considerable amount of concentrate feeds.

Livestock, also, provide productive employment for labor during the winter when little or no crop work is to be done. The use of considerable areas of pasture as well as the use of labor at favor-

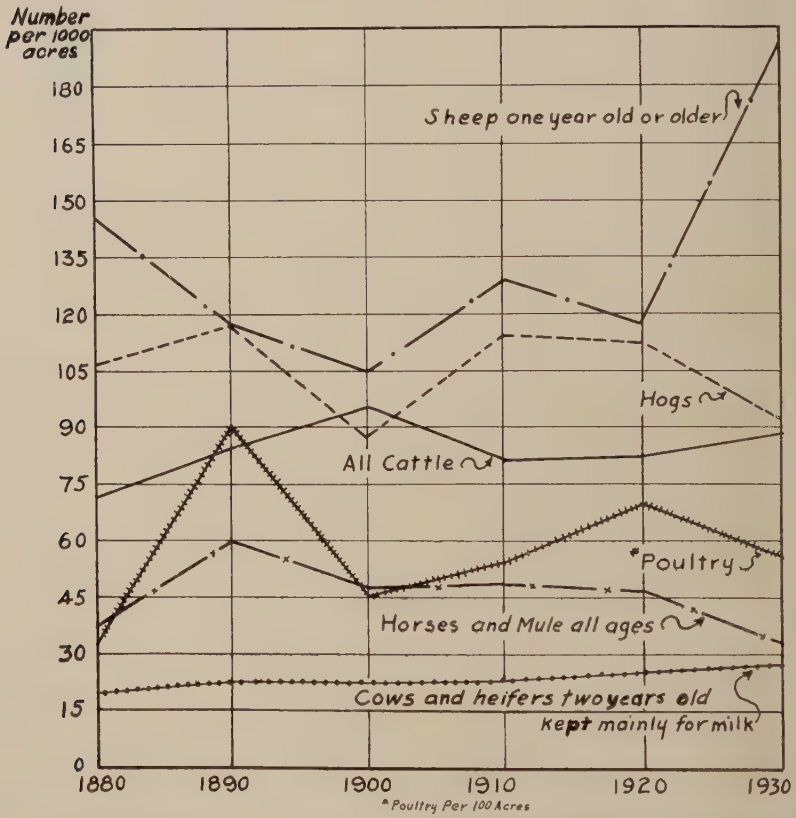


FIGURE 2. Livestock per 1000 acres of farm land. Inner Bluegrass Region, 1880 to 1930. Data from U. S. Census.

able seasons of the year was an important factor in the large expansion of the sheep enterprise and the small expansion of the cattle enterprise in the Inner Bluegrass region.

The demands of the systems of farming for labor usually are well distributed thruout the year. This is shown by Figures 3 and

4. The farm from which these data were taken is about average in size and has most of the characteristics of the usual bluegrass farm. However, tobacco occupies a smaller place and corn a larger one than often is found on farms of this size. Also tenants and hired labor perform a smaller share of the farm work than on many farms. Nevertheless, the general organization of the farm is typical of the region and the manner in which the different enterprises fit together is well illustrated.

Crop rotations normally are rather long since they usually include some years of bluegrass following harvested crops. Eight or ten years from one cultivated period to the next is quite common, especially on fields used for tobacco. Many farmers allow bluegrass to stand longer than this. When the sod is broken the land is put into cultivation for one or two years, following which it is seeded to small grain for pasture or harvest. Clovers and grasses

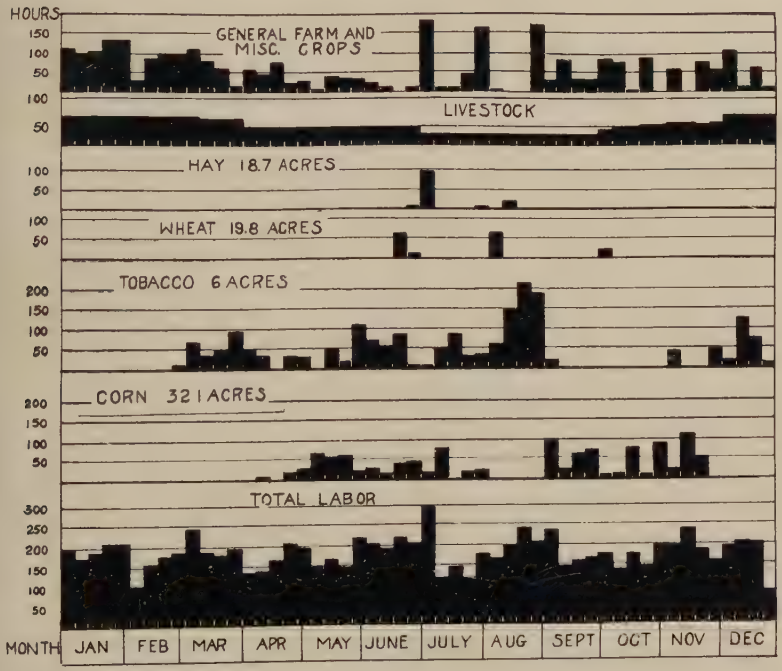


FIGURE 3. Distribution of man labor for crops and livestock on a Central Kentucky farm.

are sown in the small grain and one legume hay crop usually is removed the second year. Following this the land is pastured until the sod is broken again for cultivating.

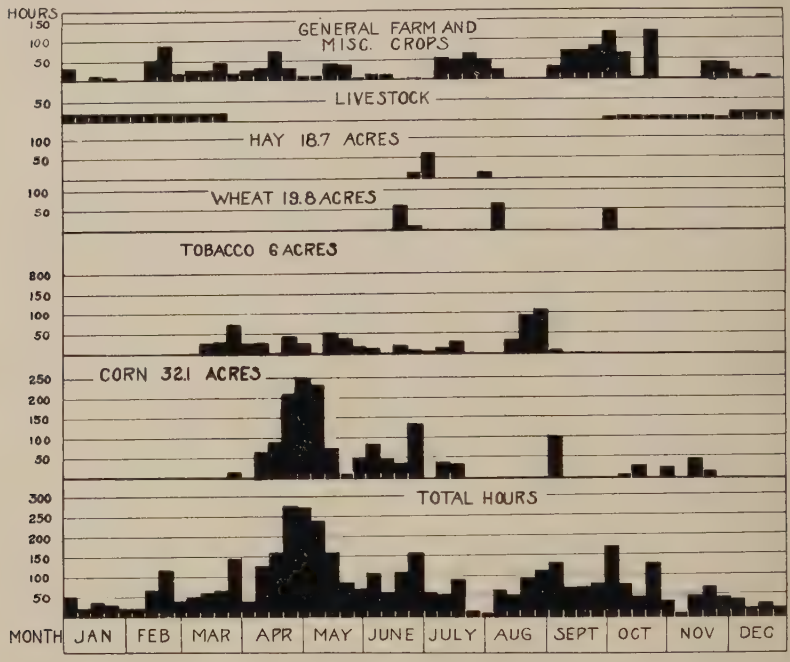


FIGURE 4. Distribution of horse work for crops and livestock on a Central Kentucky farm.

The usual cropping practices are well suited to the conditions under which they are used. The cultivated land, particularly in the inner part of the region, is seeded to cover crops over the winter thus preventing erosion and leaching. Commercial fertilizers are not generally used since they give little return in many sections, but increasing quantities of limestone are being applied. Individual farms vary greatly from established practices, and wide differences may be found in the efficiency of production methods.

Changes in commodity price relationships make it necessary for the farmer to be ever cognizant of any possible adjustments in his crop and livestock organization that may result in larger net

earnings over a period of years. This situation raises such questions as the following: In line with present prices, probable prices for the next few years, and proper soil maintenance (or improvement where necessary), should the acreage of crops be changed? What kind and number of livestock will best fit with the cash crop of a given farm in order to furnish the greatest continuous net returns to the operator? These adjustments to changing conditions are met in different ways by different farmers.

In determining the possible results of adjustments it is necessary to have information indicating the possible production for various crops and livestock. In other words, the input-output relationship must be known for each enterprise on the farm and for all enterprises considered in the adjustments. In the discussions which follow consideration will be given to important factors affecting the production and requirements of crops and livestock in this section of Kentucky. Most of the data were obtained from farms located in the inner Bluegrass counties; hence the findings are more applicable here than elsewhere, but many of the conclusions apply to the outlying portions of the region also.

TOBACCO

Burley tobacco has for many years been the principal cash crop in the Bluegrass Region of Kentucky. Since 1880 the acreage has increased steadily and at present this is one of the most important tobacco areas of the world. Special advantages of soil, climate, markets, experience and other factors for the production of burley tobacco exist in this region to a greater degree than in any other.

Man labor, horse work, and materials used for tobacco. The man labor, horse work and materials used for the production of tobacco are shown in Table 4. For each of the farms the averages are based upon the total number of years for which data were obtained. The farms are arranged in the order of yield per acre, beginning with the highest.

Yield ranged from 781 to 1317 pounds per acre. Differences on different farms are referable to differences in the natural fertility of the soil, the number of years of grass in the rotation, the vitality and uniformity of plants, seasonal conditions, and timeliness and

Table 4. Tobacco. Man labor, horse work, tractor hours and materials[1] used, and yield per acre. Route farms, 1921 to 1929, inclusive.

Farm numbers	Number of years covered	Average area of crop	Yield	Man labor	Horse work	Tractor hours	Cotton cloth	Fertilizer	Spray material[2]	Seed
		acres	lbs.	hrs.	hrs.	hrs.	yds.	lbs.	lbs.	ozs.
6	7	7.9	1317	317.2	94.9	.1	50.0	—	2.1 G .4 L	.3
10	1	3.0	1253	466.7	98.7	5.3	40.0	—	—	.3
5	2	6.0	1223	283.5	98.4	—	40.0	—	—	.3
8	1	6.4	1199	354.1	75.2	—	40.2	—	—	—[3]
20	1	11.8	1189	428.4	102.9	—	50.7	—	1.3 G	—[3]
1	5	10.0	1147	256.1	61.8	—	40.0	—	2.6 G	—[3]
9	3	13.0	1146	333.7	95.3	.4	56.0	150[4]	1.4 L	.3
4	2	10.1	1120	219.9	58.8	.9	21.0	—	2.4 G	.2
19	1	8.8	1082	284.4	100.3	—	40.0	356[4]	—	—[3]
17	3	5.0	1080	463.0	130.8	—	27.4	—	1.8 L .2 G	.5
12	1	3.3	1020	361.5	136.4	—	48.5	—	3.0 G	—[3]
24	2	5.4	966	328.1	129.1	—	49.4	42[5]	2.7 L	—[3]
11	1	8.0	920	298.1	95.9	—	25.0	—	—	—[3]
7	6	8.0	862	239.8	70.6	.5	40.0	28[5]	2.3 G .1 L	—[3]
13	4	13.1	826	258.4						
18	1	14.0	781	272.4	194.8	—	30.0	—	2.3 G	.5
					103.1	—	28.6	—	2.0 G	.2
Av.		8.7	1062	294.5	88.2	.2	40.2	—[6]	—[6]	—[6]

1 Wood for burning plant beds was usually waste material. Contract labor and equipment were used for what little plant-bed steaming was done. One farmer used 134 pounds of coke in 1927, for curing. 2 G signifies Paris green; L signifies lead arsenate. 3 Seed furnished by farm. 4 Used only one year. 5 Applied to plant bed. 6 Averages not significant since all did not use same.

thoroness of the operations in preparing the land and in tending the crop. The largest yield was produced on farm 6, largely because of the natural fertility of the soil, the long time that the field had been in bluegrass, healthy plants, timeliness and the thoroness in preparing the land and to the good methods practiced in growing and harvesting. Farm 7, on which yield was low, is deficient in natural fertility. Altho the methods practiced were good and the operations thoro and timely the land was too low in fertility to produce high yield.

Man labor ranged from 220 to 467 hours per acre; horse work, from 59 to 136 hours. On four of the farms both horses and tractors were used, the amount of tractor work ranging from less than one hour to more than five hours per acre. Most of the tobacco land is broken from bluegrass sod as early as possible in the spring.

Early-broken tobacco land requires more time to condition than if it were broken just in time to transplant. Transplanting is done generally with a setter. The amount of resetting necessary accounts in part, for some of the differences in labor requirement on the different farms. Other causes are the amount of hand cultivation necessary, the number of times it is cultivated with the plow and the time used in worming, topping, spraying and suckering. The size and efficiency of the crew, the distance from the field to the barn and the yield are largely responsible for differences in labor required to cut and house. The size and efficiency of the crew and the quality and weight of the tobacco largely determine the amount of labor required in stripping.

On Farm 1 a high yield was produced with comparatively low labor requirement. The labor requirement was kept low by timeliness and efficiency of operations, the location of the plant bed, the condition of the plants, and the nearness of the field to the barn. Large, uniform tobacco of good quality requires relatively less time to strip. Farm 17 requires an abnormally large amount of labor. This was largely because, when other crop work was not pressing, the hired man was kept in the tobacco patch and put in an excessive amount of time in such operations as hoeing, worming, topping, suckering, and spraying.

Price. The average price received by growers selling tobacco in Central Kentucky, from 1921 to 1929, was 21.1 cents per pound[8]

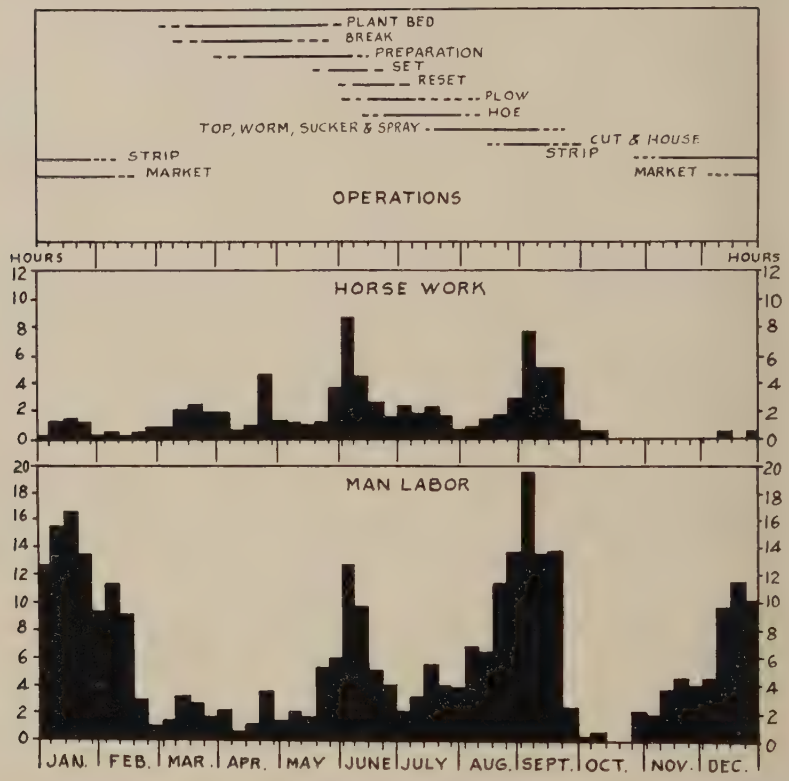


FIGURE 5. Tobacco. Seasonal distribution of man labor and horse work and usual periods of important operations. The solid lines in the top section of the chart indicate the periods when most farmers perform the operatoins. The broken lines indicate periods when the operations may be performed. The lower and middle sections indicate the hours of man labor and horse work generally required at different seasons of the year, under usual conditions. for one acre of the crop.

while the average price received by the farms furnishing the data for this study was 22.8 cents per pound. The prices received by the different farms in the study are shown in Table 5. As indicated by the prices received, the farms on which the largest yields were obtained also produce higher-quality tobacco.

8 Average price calculated from data compiled by R. M. Barker Tobacco Company, Incorporated, Carrollton, Kentucky.

Table 5. Tobacco. Gross price per pound, 1921 to 1936, inclusive.

Year grown	Sold at Lexington	Sold at Paris	On route farms
	cents	cents	cents
1921	21.31	—[1]	19.30[2]
1922	29.78	—[1]	24.74[2]
1923	22.50	—[1]	19.39[2]
1924	22.57	—[1]	20.47[2]
1925	20.99	—[1]	19.90[2]
1926	14.31	—[1]	15.11[2]
1927	28.27	28.17	31.07
1928	33.19	34.74	29.42
1929	22.46	22.19	22.16
1930	16.96	17.44	—[3]
1931	10.34	10.41	—[3]
1932	13.37	14.13	—[3]
1933	12.31	12.10	—[3]
1934	18.56	20.17	—[3]
1935	19.78	20.50	—[3]
1936	36.56	38.85	—[3]

1 No sales at Paris. Receiving point for Burley Tobacco Growers Association. 2 Total payments, except deductions for warehouse expenses, reserve fund and stock assessments. 3 No cooperators for these years.

Production requirements for tobacco. The data shown in Table 6 together with experimental data and other information relating to the production of Burley tobacco were used in arriving at the expected normal requirements for producing this crop, shown in Table 6. The yield is based upon records obtained from farms studied, results of experiments conducted at the Kentucky Agricultural Experiment Station at Lexington, and experience of farmers thruout the area to which this study is applicable. It is the yield typically obtained by the use of good practices and rotations including legumes followed by three or more years of bluegrass, coupled with the use of manure and crop residues. Tobacco does better after bluegrass than after any other crop. On most farms in the area a good tobacco rotation involves an application of limestone following the tobacco and on many farms a complete tobacco fertilizer.[9] The man labor and horse work shown in Table 4 are for growing the tobacco, cutting and housing, and stripping and marketing. One hundred and sixteen hours of man labor and 61 hours of horse work per acre are assigned for growing, 48 hours of

9 Kentucky Agricultural Experiment Station Bulletin No. 331, page 262.

man labor and 21 hours of horse work per acre for cutting and housing and 130 hours of man labor and 6 hours of horse work per acre for stripping and marketing.

Relation between tobacco and other enterprises. The man labor and horse work requirements of tobacco are relatively heavy thruout the year. For this reason tobacco, directly or indirectly, conflicts with practically all the other crops grown on the farm. Preparation of the plant bed comes in early spring and just at the time when farmers do their spring plowing. The field preparation for tobacco conflicts with the preparation for corn, soybeans and other crops which require early spring preparation. The transplanting comes approximately at the same time as the seeding of soybeans, the early cultivation of corn and the first cutting of alfalfa. The cultivation with plow and hoe and worming, topping, suckering, and spraying interfere with the cultivation of corn, the harvesting of small grain and the cutting and putting up of grass hay, clover hay and second cutting of alfalfa. Cutting and housing usually come when there is not much work to be done on the other crops. Being an air-cured type, Burley tobacco requires little attention from the time it is put into the barn until it is ready to strip, a period of about six or eight weeks. The stripping is done during the winter and does not conflict with any other crop work except corn.

Table 6. Tobacco. Production requirements per acre for an assumed yield of 1100 pounds.

Kind	Amount
Man labor, hours	300
Horse work, hours	90
Wood for plant bed[1]	—
Seed, ounces	.3
Cotton cloth, yards[2]	40
Spray material, pounds[3]	2.5
Building expense, dollars[4]	16.00
Equipment expense, dollars[4]	3.15

1 Wood furnished by the farm, of little or no value. 2 Usually replaced every two years. 3 Mostly Paris green. 4 Depreciation, repairs, insurance, interest and taxes.

CORN

Corn occupies a less important place in the Bluegrass Region than in most other parts of Kentucky; nevertheless, it is produced

more widely than any other crop, occupying approximately two-fifths of the total crop acreage harvested each year. It is used principally as a feed for hogs, cattle and workstock. In addition to the corn produced locally considerable quantities are shipped in from northern states.[10]

Most of the corn is cut and put into the shock. Both the cutting and husking, however, normally are done by contract labor so that the labor of harvesting does not conflict with other farm work. Less than five percent of the corn is used for silage, while the acreage hogged down is no greater than that put into the silo. Practically no corn is harvested from the standing stalk, it being customary to prepare all cultivated land for seeding small grain in the fall.

Requirements prior to harvest. The man labor, horse work, tractor work and seed used for corn prior to harvest, on farms where records were kept from 1921 to 1929, are shown in Table 7. The averages for each farm include the total numbers of years for which data were obtained. The farms are arranged in the order of yield per acre, beginning with the highest.

The yields ranged from 30 to 50 bushels, averaging 42 bushels. Important factors influencing yield were the natural fertility of the soil, the cropping systems followed and the care used in performing the various operations. Commercial fertilizers were not generally used, but on most farms where larger yields were obtained good use was made of stable manure. Also, the land was improved by the winter feeding of roughages to livestock upon it during the period that it was in pasture, especially the less fertile portions of the fields. On Farm 2, where a large average yield was obtained, the cropping system includes legumes. Altho the rotation is quite short, good yields were maintained by heavy applications of manure and wise use of cover crops during the winter. No commercial fertilizer is used. On Farms 25, 5, 9, and 1, where the yields obtained were among the highest in the study, the cropping systems are typical of the better farms in the region. Each of the rotations includes legumes, followed by four years or more of bluegrass for seed and pasture.

10 Detailed data obtained from 27 farm records covering the period from 1921 to 1928 show that only 95 percent of the corn which was fed was home-grown, the remainder being purchased.

The man labor used for corn prior to harvest ranged from 10 to 24 hours per acre and the horse work from 9 to 51 hours per acre. On nine of the farms tractor work was used in addition to horse work, the amount ranging from less than an hour to almost four hours per acre. All the corn land was plowed, most of it being turned in the spring. Planting was usually done with a two-row check planter and in most cases the two-horse cultivator was used for cultivating. The principal reasons for differences in labor requirements prior to harvest were the timeliness and thoroness of the operations, size of the implement and number of horses or size of tractor used, character of the soil, size and shape of fields and distance to the field from the farmstead. On Farm 2 on which

Table 7. Corn prior to harvest. Man labor, horse work, tractor work and seed, and yield per acre. Route farms, 1921 to 1929, inclusive.

Farm number	Number of years covered	Average area of crop	Yield	Man labor	Horse work	Tractor work	Seed
		acres	bus.	hrs.	hrs.	hrs.	lbs.
35	1	41.8	50.0	26.0	50.7	—	8.0
3	2	42.8	48.1	13.6	22.9	1.0	8.8
5	2	53.7	47.8	14.9	30.8	—	7.3
2	5	27.4	47.2	10.1	9.2	1.7	8.1
9	7	62.0	45.4	18.4	30.4	1.3	7.4
24	2	16.0	44.6	21.4	40.9	—	7.4
14	2	19.0	44.2	18.5	38.5	—	6.9
22	5	16.1	44.2	23.2	22.8	3.9	8.5
1	8	38.0	44.0	14.8	33.3	—	8.0
21	3	39.3	43.6	23.3	42.5	.2	7.0
26	3	35.2	43 3	27.2	42.8	—	8 3
16	4	24.9	42.3	17.2	35.6	—	6 8
10	3	79.9	42.1	13.6	25.8	.7	6.1
17	3	26.9	42.0	22.1	49.1	—	6.3
6	9	37.8	41.3	12.8	25.1	.5	7.7
8	1	49.9	39.9	11.5	28.1	—	6.7
4	2	34.0	39.7	10.6	13.4	1 8	8.2
7	7	28.2	39.1	12.8	24.5	1.0	6 8
12	1	54 8	37 6	15 8	29.4	—	6 2
18	1	34.0	37.1	18.1	36.9	—	6.8
19	3	41.1	34.3	19.6	36.2	—	7.7
15	1	69.5	33.7	12.6	31.3	—	7.1
27	1	15.1	33.6	32.9	34.9	—	8.3
13	4	32.6	33.1	16.8	34.1	—	7.7
11	1	19.4	31.9	30.9	47.6	—	8 4
20	1	64.6	30.4	16.9	38.3	—	6.2
23	1	14.5	30.0	15.6	39.8	—	7.8
Average		37.2	41.8	16.4	30.4	.6	7.3

small amounts of man labor and horse work were used, all the land was broken and prepared with a tractor. The operations of disking and harrowing were performed at the same time by attaching the disk and the harrow to the tractor in tandem. On Farms 3, 5, 1, 10 and 7 the corn fields were large and well shaped and most of the tillage operations were timely and thoro. On Farm 22 the fields were large and well shaped and the operations timely but, on account of the use of extreme care and insistence upon perfect thoroness in these operations a large amount of labor was used. On Farm 11 the high labor requirements were due to unfavorable topography and character of the soil, small, poorly shaped fields and the use of small teams and tools.

Man labor and horse work used for harvesting corn. The man labor and horse work used in harvesting corn cut and shocked and husked from the shock are shown in Table 8. About four-fifths of the corn grown in Central Kentucky is harvested in this way but on account of the wide use of contract methods in cutting and shucking, the number of acres on which complete labor reports are available is quite limited. For this reason the table is shown by operations and the averages include all acreages on which the different operations were performed by regular labor.

On Farm 7 the smallness of the amounts of man labor and horse work used for harvesting was due largely to the efficiency of the operator in performing the different operations. On Farms 13, 19 and 4 the low requirements were due to the speed at which the men worked and the nearness of the fields to the crib.

Production requirements for corn harvested for grain. The data shown in Tables 1 and 2, together with experimental data and other information relating to the production of corn for grain were used in arriving at the normal requirements for producing this crop. These requirements are shown in Table 9.

The yield is based upon records obtained from farms studied, results of rotation and fertilizer experiments conducted at the Kentucky Agricultural Experiment Station, Lexington, and the experiences of a large number of farmers located in the area to which this study is applicable. It is made possible by the use of good practices and rotations including legumes. On most farms in Cen-

Table 8. Corn harvesting. Man labor and horse work used and yield per acre. Route farms, 1921 to 1929, inclusive.

Farm number	Cutting				Shucking				Hauling				
	Number of years covered	Average area of crop	Yield	Man labor	Number of years covered	Average area of crop	Yield	Man labor	Number of years covered	Average area of crop	Yield	Man labor	Horse work
		acres	bus.	hrs.		acres	bus.	hrs.		acres	bus.	hrs.	hrs.
25	1	2.7	50.0	9.3	—	—	—	—	1	30.1	50.0	4.3	10.8
5	2	1.3	50.0	10.3	2	13.5	46.0	10.2	2	53.7	47.9	5.0	7.7
19	1	10.0	48.5	6.3	2	26.2	35.1	12.0	2	26.2	36.1	3.4	6.0
24	2	10.0	48.1	8.2	2	16.0	44.6	12.5	2	15.0	45.0	3.8	6.6
26	3	27.4	47.7	10.0	3	27.4	47.7	20.0	3	27.4	47.7	2.5	4.5
9	4	21.8	46.1	5.3	4	21.2	46.5	8.7	7	21.2	49.1	4.7	7.9
2	3	8.6	45.9	4.4	4	14.8	47.4	10.9	5	18.4	48.0	2.9	4.3
16	2	1.2	43.4	8.8	1	5.8	34.8	10.9	2	24.9	47.7	4.6	9.3
21	1	.8	40.0	12.9	1	1.6	50.0	16.2	3	40.2	43.4	4.3	8.4
4	1	15.1	39.1	6.5	1	46.2	39.1	11.4	2	33.4	40.4	3.5	7.2
7	3	2.3	38.6	4.4	3	10.0	39.3	9.7	6	26.1	40.4	2.4	4.8
13	2	25.2	30.9	6.1	2	34.8	34.1	11.8	4	29.3	32.6	2.5	5.0
20	1	10.6	30.4	8.0	1	10.6	30.4	9.7	1	61.0	29.7	4.8	7.9
10	—	—	—	—	2	5.1	53.9	14.5	3	69.7	36.2	3.0	4.9
1	—	—	—	—	1	1.0	50.0	11.3	5	32.0	53.3	4.2	5.3
3	—	—	—	—	—	—	—	—	1	44.8	48.6	3.4	6.8
6	—	—	—	—	3	1.9	43.5	17.7	8	38.8	42.0	3.4	5.2
22	—	—	—	—	—	—	—	—	2	14.0	39.0	5.4	8.0
12	—	—	—	—	1	3.1	37.4	14.2	1	50.8	37.4	4.0	7.5
17	—	—	—	—	1	3.0	35.3	19.0	3	16.0	40.8	4.6	9.2
15	—	—	—	—	—	—	—	—	1	44.5	33.7	3.2	3.2
Average		12.9	42.5	7.0	—	15.4	42.4	12.6	—	31.8	42.5	3.6	6.0

tral Kentucky this involves treatment with limestone, and on some farms the application of superphosphate in addition. Provision is made for the use of manure and crop residues.

The man labor and horse work are for growing the corn, cutting and husking by hand and hauling the grain to the crib. Fifteen hours of man labor and 32 hours of horse work are included for growing, up to harvest, and 22 hours of man labor and six hours of horse work for harvesting.

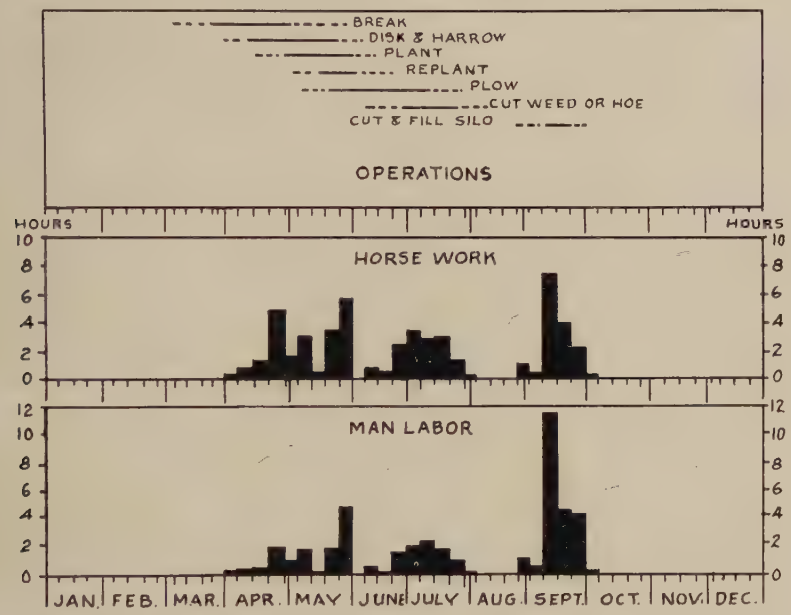


FIGURE 6. Corn. Seasonal distribution of man labor and horse work and periods of important operations (see explanation under Figure 5).

Relation between corn harvested for grain and other enterprises. The heaviest man labor and horse work requirements for corn are in preparing the land and planting, in April and early May, cultivating in June and early July, cutting in September and husking in October and November. The preparation of the land and planting follow the seeding of spring oats and precede the setting of tobacco and planting of soybeans. However, since these

operations come at approximately the same time as similar operations for tobacco and soybeans, heavy demands may be made upon the labor supply at this period when one or more of these crops are grown in connection with corn. While the cultivating of corn and tobacco come at about the same time the heaviest part of it is over before the worming and topping period for tobacco and the harvesting of mixed clover hay. In harvesting, the cutting of corn follows the cutting and housing of tobacco but conflicts with the harvesting of soybean hay. The shucking is done at a time when there is no other field work to be done.

Table 9. Corn harvested from the shock. Production requirements per acre for an assumed yield of 45 bushels of ears and 13 shocks of stover.[1]

Kind	Amount
Man labor, hours	37
Horse work, hours	38
Seed, pounds	7
Equipment expense, dollars	1.33

1 Approximately 2500 pounds stover, 13 shocks cut 16 hills square.

Corn fits well into most of the cropping systems of the area. Being clean cultivated it is an excellent crop with which to rid the land of undesirable plants and at the same time it makes for easy and economical seeding of small grain just following. Altho wheat yields less after corn than after tobacco it nevertheless produces satisfactory yields following corn. On most farms corn provides the major part of the feed for hogs and poultry and the great bulk of the grain ration for cattle, sheep and workstock. The stover is utilized to good advantage by cattle and workstock.

CORN SILAGE

The man labor, horse work, and tractor hours used in filling silos are shown in Table 10. The requirements for silage corn prior to filling are approximately the same as those shown in Table 7 for corn prior to harvest.

The yield of corn used for silage ranged from 5 to 10 tons per acre. The hours per acre of man labor used in filling silos ranged from 19 to 30, the horse work from 11 to 22 and the tractor work from 1 to 4. The principal reasons for differences in the amounts

of these items were yield of silage per acre, distance from the silo to the field, size and condition of equipment, and the size of the crew and the way it was managed.

Table 10. Corn silage. Man labor, horse work and tractor work used in filling silo, and yield per acre. Route farms, 1921 to 1929, inclusive.

Farm number	Number of years covered	Average area of crop	Yield per acre	Man labor	Horse work	Tractor work
2	5	6.8	10.4	30.2	18.4	3.2
1	4	18.8	7.9	22.4	19.2	2.1
7	5	5.5	7.9	21.6	19.1	3.7
11	1	5.0	7.6	19.8	10.8	1.8
10	3	15.0	7.4	19.7	17.4	2.4
9	8	13.1	7.2	24.3	14.0	1.6
27	1	14.1	7.0	34.0	22.0	3.5
26	3	7.9	6.7	24.4	15.3	1.9
23	1	14.5	4.6	19.4	11.8	1.4
Average		11.5	7.6	23.8	16.6	2.2

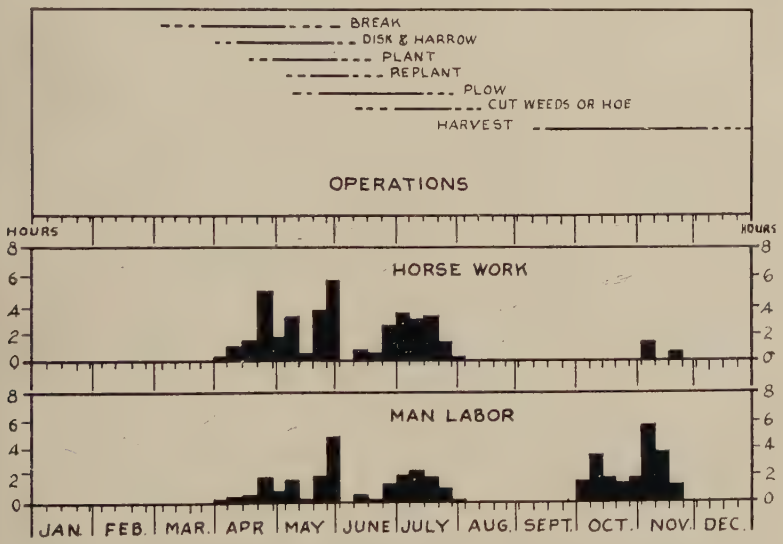


FIGURE 7. Corn silage. Seasonal distribution of man labor and horse work and periods of important operations (see explanation under Figure 5).

Production requirements for corn silage. Man labor, horse work, seed and other requirements for producing an acre of corn silage are shown in Table 11. The yield is based upon conditions

and practices similar to those described under corn harvested for grain. Land that produces 45 bushels of corn generally yields eight tons of silage per acre.

Table 11. Corn silage. Production requirements per acre. Assumed yield, 8 tons.

Kind	Amount
Man labor, hours	35
Horse work, hours	48
Tractor, hours	2
Seed, pounds	10
Building expense (silo), dollars	2.50
Equipment expense, dollars[1]	2.18

1 Both regular and special equipment, excluding tractor.

The man labor and horse work are for growing the corn and filling the silo, 15 hours of man labor and 32 hours of horse work being used prior to harvest and 20 hours of man labor and 16 hours of horse work for filling the silo. Approximately two hours of tractor work is required in silo filling. The cost of the use of the tractor is usually about one dollar per hour. The equipment expense includes depreciation, repairs and insurance on equipment used in growing the corn and filling the silo. It does not include interest and taxes.

Relation of corn silage to other enterprises. Since the silo usually is filled with corn grown in one of the regular corn fields, silage corn, prior to filling, bears the same relation to other enterprises as does other corn prior to harvest. Silo filling which comes during the early part of September conflicts with the last part of tobacco housing and the harvesting of soybeans and alfalfa hay but precedes the cutting of other corn and the seeding of small grain. Like corn harvested for grain, corn silage fits well into most of the cropping systems of the region.

WHEAT

Average of wheat declined materially from 1920 to 1930. However, it is the most important cash crop in the area except tobacco. The straw, when baled, has a good market value created by the demand of the breeders of horses, for bedding. On some farms rye is used instead of wheat, because it is not only an excellent cover

Table 12. Wheat. Man labor, horse work, and materials used and yield per acre, per year. Route farms, 1921 to 1929, inclusive.

Farm number	Number of years covered	Average area of crop	Yield		Man labor			Horse work			Tractor hours			Seed	Twine
			Grain	Straw	Up to harvest	Harvesting	Total	Up to harvest	Harvesting	Total	Up to harvest	Harvesting	Total		
		acres	bus.	lbs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	bus.	lbs.
4	2	57.4	24.0	809	2.7	3.4	6.1	4.2	3.6	7.8	.1	—	.1	1.2	2.1
1	4	63.3	22.5	1393	4.0	2.2	6.2	11.0	2.7	13.7	.2	—	.2	1.3	2.4
9	2	36.2	19.7	1430	1.9	3.8	5.7	3.0	3.2	6.2	.7	—	.7	1.2	2.6
18	1	12.2	17.1	494	2.9	4.1	7.0	9.0	6.6	15.6	—	—	—	1.3	1.6
16	4	25.7	17.0	987	3.5	2.5	6.0	6.6	2.4	9.0	—	—	—	1.4	2.5
21	2	31.6	16.6	702	3.3	4.0	7.3	9.5	3.5	13.0	—	—	—	1.5	1.8
14	1	85.9	16.0	1164	4.5	2.4	6.9	13.3	3.4	16.7	—	—	—	1.2	2.1
17	2	72.0	15.4	771	1.9	2.2	4.1	6.1	2.6	8.7	—	—	—	1.2	1.6
22	4	50.7	14.8	835	5.6	3.4	9.0	7.8	2.7	10.5	2.1	—	2.1	1.4	1.6
6	8	49.2	14.3	993	3.0	2.6	5.6	7.5	2.6	10.1	.2	—	.2	1.4	2.0
10	3	135.9	13.9	959	3.1	2.4	5.5	6.7	3.0	9.7	.5	—	.5	1.5	1.6
19	2	32.1	12.6	1180	3.6	3.7	7.3	8.7	3.7	12.4	—	—	—	1.8	1.4
13	2	52.6	12.1	780	2.7	3.2	5.9	7.1	2.9	10.0	—	—	—	1.3	3.9
7	6	26.2	11.7	793	2.6	2.2	4.8	7.6	2.6	10.2	.1	—	.1	1.2	1.8
26	2	21.6	11.6	1109	3.1	3.8	6.9	8.0	3.5	11.5	—	—	—	1.4	1.1
12	1	15.0	9.0	1067	3.5	3.6	7.1	9.1	4.8	13.9	—	—	—	1.3	1.6
Average		48.5	15.8	997	3.3	2.8	6.1	7.7	2.9	10.6	.4	—	.4	1.4	1.8

crop and nurse crop but provides winter and early spring pasture which is superior to wheat pasture.

Man labor, horse work and materials used for wheat. These items of expense in the production of wheat are shown in Table 12. The averages for each farm are based upon the total number of years for which data were obtained. The farms are arranged in the order of yield per acre, beginning with the highest. Yields ranged from 9 to 24 bushels per acre. Important factors influencing yield were the natural fertility of the soil, the cropping system and thoroness and timeliness in preparing the seed bed. On farms 4, 1 and 9, on which the largest yields were obtained, the cropping systems included a legume followed by three or more years of bluegrass for seed and pasture.

Table 13. Wheat. Yield per acre and price per bushel. Kentucky, 1921 to 1936, inclusive.

Year	Average yield[1] bus.	Farm price[2]	
		July 15 dollars	August 15 dollars
1921	10.0	1.22	1.18
1922	11.5	1.18	1.14
1923	12.4	1.12	1.04
1924	10.5	1.15	1.33
1925	14.5	1.56	1.57
1926	19.0	1.34	1.37
1927	10.0	1.40	1.38
1928	9.5	1.65	1.44
1929	12.4	1.18	1.29
1930	14.0	.87	.94
1931	22.0	.49	.47
1932	10.5	.44	.47
1933	12.0	.98	.90
1934	13.0	.87	.94
1935	10.0	.76	.82
1936	14.0	.98	1.06

1 U.S.D.A., B.A.E. Division of Crop and Livestock Estimates. 2 U.S.D.A., B.A.E. Crops and Markets.

Commercial fertilizers were not generally used on wheat, on any of the farms; however, on most of the farms on which larger yields were obtained considerable quantities of manure were used, applied to cultivated crops. Also winter feeding of stover usually was done on the less fertile portions of the field during the time when it was in pasture.

The man labor used for growing and harvesting wheat ranged from 4 to 9 hours per acre and the horse work from 6 to 17 hours per acre. On six of the farms tractor work was used in addition to the horse work, the amount ranging from less than an hour to more than two hours per acre. Most of the land seeded to wheat had been in a clean-cultivated crop, making disking the only necessary operation before seeding which in practically every case was done with a grain drill. The wheat was harvested by means of a binder. The principal reasons for the differences in labor requirement on the different farms were the timeliness and thoroness of the seed-bed preparation, size of implements, number of horses or size of tractor, size and shape of the field and character of the soil. On Farm 17 on which small amounts of man labor and horse work were used, all the land was double disked with a four-horse disk and seeded with a 7-foot drill. On Farms 9, 6 and 7 the wheat was grown on fields of good shape and size and the operations were timely and thoro and were performed economically. On Farm 22 relatively large amounts of man labor and horse work were used and the largest amount of tractor work was used.

Production requirements for wheat. The data shown in Table 12 together with experimental data and other information relating to the production of wheat were used in determining the requirements for producing this crop, shown in Table 14. The yield is based upon records obtained from farms studied, results of rotation and fertilizer experiments conducted at the Kentucky Agricultural Experiment Station, Lexington, and the experiences of a large number of farmers located in the area to which these data are applicable. The yield is dependent upon the use of good practices and rotations, including legumes. It is necessary on many farms in central Kentucky to treat the land with limestone. Altho provision was made for the use of manure and crop residues, on some farms in the area, application of superphosphate is needed. The man labor and horse work are for growing the wheat, cutting with a binder and shocking. Three hours of man labor and eight hours of horse work per acre are allowed for growing and three hours of man labor and three hours of horse work per acre for cutting and shocking.

Table 14. Wheat. Production requirements per acre. Assumed yield, 17 bushels of grain and 1200 pounds of straw.

Kind	Amount
Man labor, hours	6
Horse work, hours	11
Seed, bushels	1.3
Twine, pounds	2
Contract threshing per bushel, cents	17
Equipment expense, cents	40

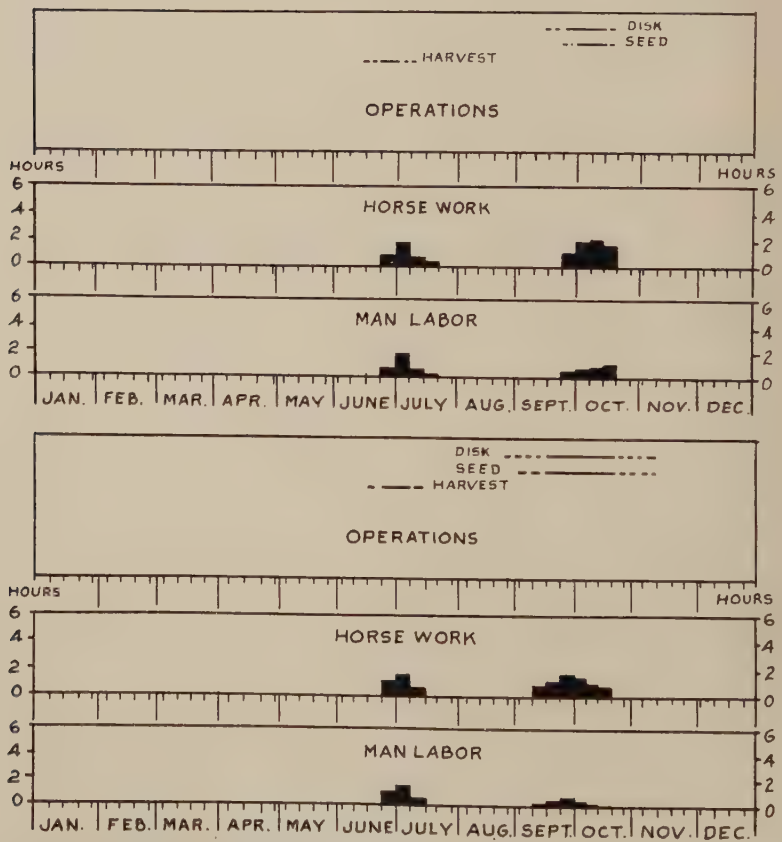


FIGURE 8 (Upper). Wheat. Seasonal distribution of man labor and horse work and periods of important operations (see explanation under Figure 5).

FIGURE 9 (Lower). Rye. Seasonal distribution of man labor and horse work and periods of important operations (see explanation under Figure 5).

Relation of wheat to other enterprises. The heaviest man-labor and horse-work requirements for wheat are in preparing the land and seeding, in late September and the first half of October, and in cutting and shocking, in the last half of June. Preparation of the land and seeding follow harvesting soybean hay, cutting and shocking corn, and seeding rye and barley. Cutting and shocking wheat comes just after the harvest of barley, at about the same time as the second cutting of alfalfa. This operation also conflicts with cultivation of corn and cultivation and worming of tobacco.

RYE

In recent years, rye has grown rapidly in favor with farmers thruout the entire area and has replaced much wheat, tho it is not grown as a cash crop. Because of its excellence as a cover crop, nurse crop and pasture crop, some rye is found on most farms in the area. Since rye pasture is available so much earlier than grass pasture its use goes hand in hand with the production of grazing livestock, especially sheep. If pastured not too late in the season, rye produces a fair yield of grain. The grain is seldom sold but is used on the farm for seed and hog feed. Rye straw when baled commands a higher price than any other straw.

Man labor, horse work and materials used for rye. These factors are shown in Table 15. The average for each farm is based upon the total number of years for which data were obtained. The yield of grain ranged from 3 to 18 bushels per acre. Differences in yield on different farms are influenced by several factors, the most important being the extent to which the grain was pastured, the natural fertility of the soil, and seasonal conditions. On Farm 7 on which the highest yield was produced, the grain was not pastured heavily and not at all after March 31. The very low yield on Farm 5 was because the grain was grazed down in the fall and spring and was damaged by a severe hail storm a short time before harvest.

For seed-bed preparation and seeding the man labor ranged from 1 to 10 hours per acre and the horse work, from 2 to 28 hours. On 7 of the farms there was tractor work which ranged from 0.2 to 5½ hours per acre. The wide range in the amount of man labor and horse work used on the different farms was because some farmers

Table 15. Rye. Man labor, horse work and materials used, and yield per acre. Route farms, 1921 to 1929, inclusive.

Farm number	Number of years covered	Average area of crop	Amount of seed	Up to harvest		Area cut	Number of years covered	Yield		Harvesting		Total		Twine
				Man	Horse			Grain	Straw	Man	Horse	Man	Horse	
		acres	bus.	hrs.	hrs.	acres		bus.	lbs.	hrs.	hrs.	hrs.	hrs.	lbs.
6	8	24.2	2.2	6.2	14.6	36.8	1	3.8	544	1.2	1.2	7.4	15.8	1.8
					.8[1]								.8[1]	
22	4	30.1	1.8	7.4	7.2	10.2	2	15.1	1133	3.0	3.4	10.4	10.6	2.0
					5.5[1]								5.5[1]	
10	3	37.1	2.0	3.3	9.2	22.1	3	12.5	1166	3.2	5.1	6.5	14.3	2.2
9	6	54.4	1.9	2.0	3.8	20.9	5	13.5	904	2.6	3.6	4.6	7.4	2.4
					.5[1]								.5[1]	
1	7	31.1	2.1	2.5	6.0	14.0	1	17.9	1743	2.8	3.7	5.3	9.7	2.5
17	1	18.8	.5	1.1	3.2	—	—	—	—	—	—	1.1	3.2	—
8	1	73.6	1.2	2.1	7.0	—	—	—	—	—	—	2.1	7.0	—
20	1	37.3	1.3	2.7	6.6	—	—	—	—	—	—	2.7	6.6	—
3	2	37.6	2.2	1.7	3.1	—	—	—	—	—	—	1.7	3.1	—
12	1	20.8	1.7	9.1	25.6	—	—	—	—	—	—	9.1	25.6	—
7	5	17.5	1.9	2.8	8.0	14.9	3	17.5	1240	2.4	2.6	5.2	10.6	2.0
					.3[1]								.3[1]	
23	1	30.0	2.0	8.1	19.8	—	—	—	—	—	—	8.1	19.8	—
4	3	36.5	1.5	2.1	2.3	15.8	2	5.7	987	1.9	2.4	4.0	4.7	1.2
					1.1[1]								1.1[1]	
21	3	29.5	1.8	9.3	28.2	—	—	—	—	—	—	9.3	28.2	—
16	2	8.4	2.0	10.7	26.8	—	—	—	—	—	—	10.7	26.8	—
19	4	29.4	1.4	3.3	7.0	12.1	3	12.5	1060	6.1	6.3	9.4	13.3	2.1
					.2[1]								.2[1]	
24	1	14.1	1.8	3.3	7.7	—	—	—	—	—	—	3.3	7.7	—
13	3	30.6	1.3	2.4	2.9	—	—	—	—	—	—	2.4	2.9	—
25	2	56.2	2.0	4.5	14.3	33.7	1	3.6	389	7.2	5.9	11.7	20.2	1.3
5	2	42.6	1.5	4.1	3.8	—	—	—	—	—	—	4.1	3.8	—
					1.5[1]								1.5[1]	
2	3	29.0	1.6	1.8	1.8	—	—	—	—	—	—	1.8	1.8	—
					.5[1]								.5[1]	
Average		32.3	1.8	3.8	8.2	18.5		11.5	972	3.2	3.9	7.0	12.1	1.8
					.6[1]								.6[1]	

[1] Tractor hours. The figure representing tractor hours is placed below that representing horse hours.

did not break the land for rye, some broke only part and some broke all. Other factors were the use of different kinds and sizes of equipment, character of the soil and size and shape of the fields. Man hours in harvesting rye ranged from 1 to 7 per acre and horse work from 1 to 6 hours. Farm 25 used the most man labor for harvesting. The time required to shock, accounts for much of the difference. On Farm 6 on which both man labor and horse work were small, the field was close at hand, very level and of good shape.

Table 16. Rye. Yield per acre and price per bushel. Kentucky, 1921 to 1936.

Year	Average yield[1]	Farm price[2]	
		July 15	August 15
	bus.	dollars	dollars
1921	10.0	1.08	1.10
1922	11.5	1.01	1.03
1923	11.7	1.01	.98
1924	11.0	1.05	1.22
1925	12.0	1.22	1.15
1926	14.5	1.07	1.04
1927	1.05	1.14	1.11
1928	11.5	1.35	1.31
1929	9.5	1.12	1.15
1930	10.5	.75	.89
1931	13.5	.45	.45
1932	9.0	.39	.41
1933	11.0	.83	.80
1934	11.3	.74	.83
1935	8.0	.64	.65
1936	11.0	.80	.99

1 U.S.D.A., B.A.E. Division of Crop and Livestock Estimates. 2 U.S.D.A., B.A.E. Crops and Markets.

Production requirements for rye. The data shown in Table 15 together with other information relating to the production of rye were used in determining the requirements for producing this crop, shown in Table 17. Yield is based upon records obtained from farms studied and experiences of a large number of farmers located in the area. Provision was made for the use of manure and crop residues, and on some farms in the area application of superphosphate is needed also. The man labor and horse work are for the preparation of the seed bed and seeding, cutting with a binder and shocking. Three hours of man labor and eight hours of horse work per acre are for seed-bed preparation and seeding, and three

hours of man labor and three hours of horse work per acre, for cutting and shocking.

Table 17. Rye. Requirements per acre. Assumed yield, 17 bushels grain and 1200 pounds straw.

Kind	Amount
Man labor, hours	6
Horse work, hours	11
Seed, bushels	2
Twine, pounds	2
Contract threshing, per bushel, cents	17
Equipment expense, cents	40

Relation of rye to other enterprises. There is a close relation between rye and many of the crop enterprises, especially the cultivated crops, as well as some of the livestock enterprises. Since much of the rye in the area is seeded for pasture or a cover crop, the labor for harvesting is of minor importance. The heaviest man labor and horse work requirements are in preparing the seed bed and seeding, in September and October, and in harvesting about the last half of June. The period during which rye can be seeded is longer than for wheat. Beginning about August 20, it may be sown as late as October. The time of seeding rye largely depends upon the time the crop preceding the rye is harvested. Rye for late fall pasture is usually seeded earlier than that for a cover crop. The harvesting of rye conflicts with the cultivation of corn and tobacco, and comes at about the same time as the harvesting of clover hay.

BARLEY

In central Kentucky, barley doubled in acreage from 1919 to 1924. Because of the abnormal decrease in the acreage of wheat during the same period, barley increased relatively from three percent to nine percent of the total acreage in small grains harvested for grain, exclusive of oats. Practically all the barley produced in this area is used on the farm, either as feed or as seed but, like the other small grains, there is a special advantage here over other regions, in that the straw has a good cash value on the local market. The yield of barley is larger than that of wheat and the crop is an excellent substitute for corn as a feed.

Table 18. Barley. Man labor, horse work and materials used and yield per acre. Route farms, 1921 to 1929, inclusive.

Farm number	Number of years covered	Average area of crop	Seed	Up to harvest			Area cut	Number of years covered	Yield		Harvesting		
				Man	Horse	Tractor			Grain	Straw	Man	Horse	Twine
		acres	bus.	hrs.	hrs.	hrs.	acres		bus.	lbs.	hrs.	hrs.	lbs.
21	4	39.7	1.7	3.2	9.5	—	32.8	3	32.5	850	4.0	3.9	2.9
24	1	15.2	1.7	9.2	24.5	—	15.2	1	30.8	1317	2.1	2.1	2.0
22	5	25.3	1.9	5.0	7.9	2.7	22.6	4	27.5	917	3.5	4.0	2.2
4	2	11.3	1.5	5.3	11.9	.2	15.7	1	27.4	1000	2.3	3.1	2.3
5	1	12.1	1.2	2.9	8.7	—	12.1	1	25.4	743	3.3	3.0	2.1
6	3	17.2	1.8	2.3	6.4	—	20.0	2	25.1	985	2.8	2.8	1.6
7	5	13.3	1.5	3.0	9.3	—	10.5	4	23.2	1250	2.0	2.4	2.2
11	1	4.0	1.5	7.5	11.2	—	4.0	1	22.5	1000	12.0	11.0	3.8
25	1	13.8	2.0	7.6	19.5	—	13.8	1	19.9	506	8.7	9.4	1.4
19	1	39.3	2.2	3.0	6.9	.3	39.3	1	18.0	498	3.8	3.0	1.7
1	1	12.7	2.0	3.5	13.0	—	12.7	1	15.0	1260	1.5	4.1	2.0
20	1	87.8	1.3	3.0	7.4	—	78.3	1	12.0	971	3.1	3.1	.8
9	3	18.1	2.0	2.3	6.1	.3	10.5	2	9.1	954	2.4	3.1	1.4
14	1	25.0	2.0	2.4	6.0	—	—	—	—	—	—	—	—
10	1	28.0	1.6	8.4	25.3	—	—	—	—	—	—	—	—
17	1	9.1	1.4	9.9	26.4	—	—	—	—	—	—	—	—
18	1	21.0	1.4	1.7	3.3	—	—	—	—	—	—	—	—
12	1	11.6	1.6	11.0	32.4	—	—	—	—	—	—	—	—
23	1	31.6	1.5	2.9	8.3	—	—	—	—	—	—	—	—
Average		22.3	1.6	3.9	9.8	.5	20.6		23.4	932	3.4	3.6	2.0

Man labor, horse work, and materials used for barley. These items of expense in the production of barley are shown in Table 18. The average for each farm is based upon the number of years for which data were obtained. The farms are arranged in the order of yield per acre, beginning with the highest.

The yield ranged from 9 to 32 bushels per acre. Important factors influencing yields were the natural fertility of the soil, the cropping system and the thoroness and timeliness in preparing the seed bed.

On Farm 21, on which the highest yield was obtained, the rotation was only three years in duration but included a crop of clover, most of which was grazed and turned under. There was also a rye crop which was pastured and turned under. Altho this is a short rotation the land is comparatively level and the cropping system keeps the soil in a good state of fertility. All the feed crops produced are consumed on the farm and the manure is returned to the land. These factors together with the good practices employed account largely for the yield obtained.

Commercial fertilizers were not used on the barley crop on any

Table 19. Barley. Yield per acre and price per bushel, Kentucky, 1921 to 1936, inclusive.

Year	Average yield[1]	Farm price[2]	
		July 15	August 15
	bus.	dollars	dollars
1921	24.0	.64	.63
1922	28.0	.70	.76
1923	27.0	.90	.72
1924	20.0	.90	1.00
1925	22.0	.80	.89
1926	24.0	.98	.71
1927	22.5	.70	.83
1928	20.5	.91	.81
1929	23.5	.94	.98
1930	20.0	.65	.64
1931	28.0	.36	.37
1932	20.0	.36	.35
1933	23.0	.59	.58
1934	19.0	.54	.66
1935	21.0	.51	.53
1936	20.0	.67	.89

1 U.S.D.A., B.A.E. Division of Crop and Livestock Estimates. 2 U.S.D.A., B.A.E. Crops and Markets.

of the farms. On most of the farms on which larger yields were obtained, considerable quantities of manure were applied to the cultivated crops. The man labor used for growing barley ranged from 2 to 11 hours per acre and the horse work from 3 to 32 hours per acre. On four of the farms tractor work was used in addition to the horse work, the amount ranging from less than one hour to more than two hours per acre.

On most of the farms the land seeded to barley had been in a clean-cultivated crop, making disking the only necessary operation before seeding which, in practically every case, was done with a grain drill. The man labor used for harvesting ranged from 2 to 12 hours per acre and the horse work, from 2 to 11 hours. All the barley cut was harvested with a binder. The reasons for the farm to farm differences in labor requirement were the timeliness and thoroness of the seed-bed preparation, size of implements, number of horses or size of tractor used, size and shape of the fields and the character of the soil. On Farm 6, on which little man labor and horse work were used and a comparatively large yield was produced, none of the land was broken but practically all was double disked with a four-horse disk and the seed drilled in. On Farm 11 on which much man labor and horse work was used for harvesting, the field was small and irregular in shape.

Production requirements for barley. The data shown in Table 18 together with experimental data and other information relating to the production of barley were used in determining the requirements for producing this crop, shown in Table 20. The yield is based on records obtained from farms studied, results of experimental data at the Kentucky Agricultural Experiment Station, Lexington, and experiences of farmers located in the area. The

Table 20. Barley. Production requirements per acre. Assumed yield of 35 bushels of grain and 1200 pounds of straw.

Kind	Amount
Man labor, hours	6
Horse work, hours	11
Seed, bushels	1¾
Twine, pounds	2
Contract threshing, per bushel, cents	35
Equipment expense, cents	40

man labor and horse work are for growing the barley, cutting with a binder and shocking.

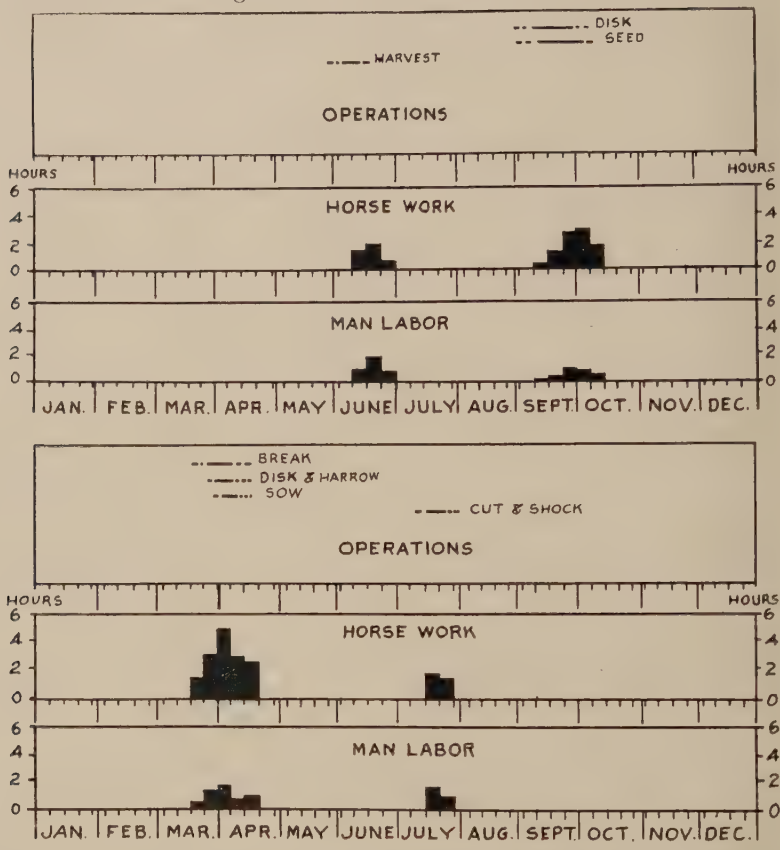


FIGURE 10 (Upper). Barley. Seasonal distribution of man labor and horse work and periods of important operations (see explanation under Figure 5).

FIGURE 11 (Lower). Oats. Seasonal distribution of man labor and horse work and periods of important operations (see explanation under Figure 5).

Relation of barley to other enterprises. The heaviest man labor and horse work requirements for barley are in preparing the land and seeding, in late September, and cutting and shocking about the middle of June. Preparation of the land and seeding come about the same time as the harvesting of soybeans, and follow the cutting and shocking of corn. Seeding comes at the same time

as for rye and wheat. However, when barley is seeded it usually takes the place of rye or wheat. Cutting and shocking usually come just before the second cutting of alfalfa or the harvesting of mixed clover and timothy but conflict with the cultivation of corn and tobacco.

OATS

Spring oats grown in central Kentucky are used exclusively for feed. Altho about five percent of the harvested-crop land is devoted to the production of oats, the crop is of minor importance because the yields obtained are relatively small. Oats provide a substitute for corn in feeding horses and mules, and in mixtures for sheep, dairy cattle and poultry.

Man labor, horse work and materials used for oats. These factors in the production of oats are shown in Table 21. Averages for each farm are based upon the total number of years for which the data were obtained. The farms are arranged in the order of total labor requirement, beginning with the highest. The yield of oats cut for grain ranged from 3 to 36 bushels per acre and from 360 to 1055 pounds of straw. The yield of oats cut to be fed in the bundle ranged from 678 to 3071 pounds per acre. Important factors influencing yield were the natural fertility of the soil, the cropping system, seasonal conditions and the thoroness and timeliness of the tillage operations. On Farm 23, on which the highest yield of grain was obtained, oats followed rye and clover. The cropping system on this farm always included a legume. The next highest yield of grain was on Farm 7 which had received an application of two and one-fourth tons of limestone. The largest yield of straw was on the same farm. The largest yield of oat hay was on Farm 7 and this, like the field cut for grain, had received an application of two and one-fourth tons of limestone.

The man labor used for all oats up to threshing ranged from less than three or more than 12 hours per acre and the horse work ranged from 4 to 22 hours per acre. On five farms there was tractor work in addition to the horse work and this ranged from less than one hour to four hours per acre. On Farm 12 the labor requirement was small. The oats which followed a wheat failure were broadcast

Table 21. Oats. Man labor, horse work and materials used and yield per acre. Route farms, 1921 to 1929, inclusive.

Farm number	Number of years covered	Average area of crop	Seed	Up to harvest			Area cut	Number of years covered	Yield			Harvesting			Twine
				Man	Horse	Tractor			Grain	Straw	Sheaf oats	Man	Horse	Tractor	
		acres	bus.	hrs.	hrs.	hrs.	acres		bus.	lbs.	lbs.	hrs.	hrs.	hrs.	lbs.
9	4	10.6	2.5	6.0	12.0	.8	10.6	4	19.1	826	1220	6.8	5.8	.4	4.8
18	1	14.0	2.1	7.1	14.3	—	14.0	1	—	—	1429	5.0	5.7	—	.7
22	2	5.0	1.8	7.0	4.5	4.0	5.0	2	—	—	1800	3.0	3.8	—	1.9
16	1	4.3	2.1	3.6	7.2	—	4.3	1	—	—	2791	6.3	3.7	—	1.9
23	1	19.0	2.0	6.4	13.7	—	19.0	1	35.9	1055	317	3.2	3.2	—	2.7
8	1	29.1	2.6	7.7	17.5	—	29.1	1	4.6	630	1178	1.8	2.2	—	1.9
14	1	12.0	2.0	6.6	19.6	—	12.0	1	—	—	1667	2.7	3.3	—	2.7
1	2	31.1	2.0	4.3	10.7	—	44.3	1	3.4	361	678	1.9	2.4	—	2.2
2	1	8.0	1.9	3.8	3.2	1.3	8.0	1	—	—	1500	1.8	1.4	—	2.7
7	3	19.8	1.8	2.6	4.2	1.0	9.8	3	—	—	3071	2.5	3.1	—	2.2
20	1	8.0	2.0	2.2	5.6	—	8.0	1	—	—	1500	2.5	2.5	—	2.5
12	1	23.0	1.7	1.0	1.7	.4	23.0	1	31.2	870	—	2.9	2.4	—	1.3
3	1	23.4	1.3	2.0	5.6	—	23.4	1	—	—	726	1.8	1.9	—	1.9
4	1	7.0	2.1	1.4	2.8	—	7.0	1	—	—	2000	1.1	2.3	—	2.7
17	1	5.1	2.0	5.9	21.6	—	—	—	—	—	—	—	—	—	—
5	1	22.4	2.0	3.8	7.8	—	—	—	—	—	—	—	—	—	—
Average		15.3	2.0	4.4	9.3	.4	11.5	—	9.4	660	1164	3.2	3.2	.1	2.7

and disked in. The fact that the land was not broken, largely explains the extremely small labor requirement. Farm 9 used the largest amount of labor. These oats were grown off the place. The land was broken, double disked, harrowed and the seed drilled in. The thoroness of the seed-bed preparation and the distance to the field account largely for the amount of labor used.

Production requirements for oats. Requirements for oats harvested for grain or to be fed in the bundle[1] are shown in Table 22. The data studied and other information indicate that a yield of 35 bushels per acre may be expected when two bushels of seed are sown and good methods are practiced. All land devoted to the production of oats is not broken. When the land is broken, approximately 6 hours of man labor and 13 hours of horse work per acre are required in preparing the seed bed and seeding, and 3 hours of man labor and 3 hours of horse work per acre are required to harvest. On unbroken land which was in a cultivated crop the previous season, approximately 2 hours of man labor and 5 hours of horse work per acre are required in preparing the land and seeding, and 3 hours of man labor and 3 hours of horse work per acre to harvest.

Table 22. Oats. Production requirements per acre for an assumed yield of 35 bushels of grain and 1000 pounds of straw.

Kind	Amount
Man labor, hours	9
Horse work, hours	16
Seed, bushels	2
Twine, pounds	2.5
Contract threshing per bushel, cents	35
Equipment expense, cents	60

Relation of oats to other enterprises. The heaviest man labor and horse work requirements for oats are in preparing the land and planting in late March and early April and in harvesting about the middle of July. Preparation and planting precede preparation for corn but come about the same time as making tobacco beds. Harvesting conflicts with the cultivation of tobacco both with plow and hoe and comes immediately after the harvesting of mixed and clover hay.

1 Since practically all the threshing is done by contract the labor is not included which makes the labor requirements the same for oats cut for grain or cut to be fed in the bundle.

SOYBEANS

In central Kentucky the number of acres used for the production of soybeans has increased rapidly within the last decade. On all farms in the nine most centrally located counties of the region, in 1924, there was approximately one acre of soybeans to every 20 acres of all hay while, in 1919, there was only one acre to every 80 acres of all hay. In this area soybeans are used chiefly as a feed for dairy cows and sheep, and to a limited extent for beef cattle. Only rarely are they grown for seed.

Man labor, horse work, and seed used for soybean hay. These factors in the production of soybean hay are shown in Table 23. On the farms for which detailed data were obtained for one or more years the yields ranged from 860 pounds per acre to 5840 pounds per acre. Man labor ranged from 10 to 40 hours per acre and horse work from 23 to 54 hours. On three of the farms horse work was as little as 15 and 18 hours per acre but a tractor was used on these, ranging from less than one hour to more than three hours per acre.

On Farm 22 on which a yield of 5840 pounds was obtained the soybeans were grown on unlimed soil. The seed were inoculated and drilled in at the rate of 1.4 bushels per acre. The seed bed was thoroly prepared, free from filth, and a good stand was obtained. Since the seed were drilled, cultivation was not necessary. Six man hours, six horse hours and three tractor hours per acre were used prior to harvest, and nine man hours and 11 horse hours per acre for harvesting.

On Farm 2 an average yield of 3880 pounds per acre of soybean hay was obtained during the two years for which data were available. This field was unlimed but had received 8 to 10 tons of manure. The soybeans were inoculated. Rye was seeded in this field in the fall following the corn crop and was pastured and turned under the following spring for the soybean crop. The seed bed was thoroly prepared both years and in the same manner. Both crops were planted in rows and cultivated one time. There was the same amount of seed used each year which was nine-tenths of a bushel per acre. Prior to harvest, eight man hours, eight horse hours and three tractor hours per acre were required while to harvest the

Table 23. Soybean hay. Man labor, horse work and seed used and yield per acre. Route farms, 1921 to 1929, inclusive.

Farm number	Number of years covered	Average area of crop	Up to harvest				Acres harvested	Yield	Harvesting			Total		
			Seed	Man labor	Horse work	Tractor hours			Man labor	Horse work	Tractor hours	Man labor	Horse work	Tractor hours
	no.	acres	bus.	hrs.	hrs.	hrs.	acres	lbs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
								Hauled in loose						
22	2	5.1	1.4	6.5	5.8	3.2	5.1	5840	10.2	11.8	—	16.7	17.6	3.2
23	1	19.0	1.3	9.5	24.0	—	19.0	4200	9.6	8.4	—	19.2	43.0	—
6	1	4.4	1.5	8.6	20.8	—	4.4	4120	10.8	9.6	—	19.3	30.4	—
2	5	20.2	.9	8.1	8.0	3.1	20.2	3880	11.4	6.9	.1	19.4	14.9	3.2
10	1	3.7	.3	8.3	15.8	—	3.7	2180	6.3	7.1	—	14.6	22.9	—
13	2	17.4	1.1	7.9	17.1	—	17.4	2120	14.2	14.4	—	22.2	31.5	—
19	1	14.3	.7	8.6	19.6	—	14.3	2100	12.2	12.8	—	20.8	32.4	—
25	1	7.2	1.4	11.9	28.6	—	7.2	2100	26.6	25.8	—	40.5	54.5	—
17	1	6.2	1.0	9.7	24.2	—	6.2	1300	7.3	7.3	—	16.9	31.4	—
1	1	14.0	1.9	6.8	20.4	—	14.0	860	3.8	6.4	—	10.6	26.8	—
Average		13.7	1.0	8.9	15.4	1.6	13.4	3240	11.4	9.7	—	20.3	25.1	1.6
								Baled in field						
22	2	2.2	2.0	8.4	11.5	2.5	2.2	5333	25.0	13.6	10.0	33.4	25.1	12.5
1	1	10.0	2.0	5.0[1]	15.3	—	10.0	4000	18.0	9.0	—	23.0	24.3	—
9	2	18.5	2.0	6.1[1]	17.0	.7	12.5	2680	11.9	8.0	.8	18.0	25.1	1.5
7	2	11.0	2.0	4.5[1]	10.4	.4	7.5	1800	5.8	6.8	.3	10.3	17.2	.7
Average		10.5	2.0	5.5	14.4	.6	7.8	3000	12.5	8.3	1.2	17.9	22.7	1.8

1 All the land was not broken.

crop 10 man hours, six horse hours and less than one tractor hour per acre were used.

Table 24. Soybean hay. Production requirements per acre for an assumed yield of 4000 pounds.

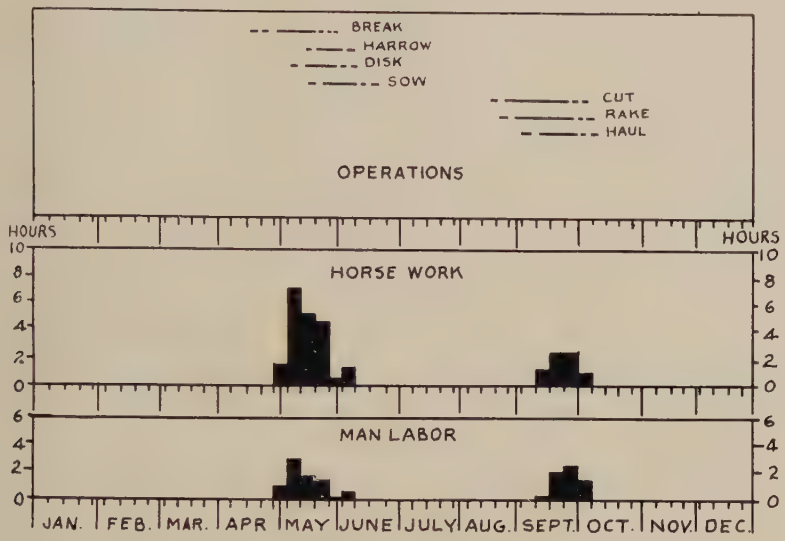
Kind	Amount
Man labor, hours	18
Horse work, hours	30
Seed, bushels[1]	1.25
Inoculation[2]	
Equipment expense, dollars[3]	1.00

1 One of the standard hay varieties. (Ky. Extension Circular No. 292). 2 Usually with soil from a field that is known to be inoculated. If the field to be sown is already inoculated this operation is not necessary. 3 Both regular and special equipment excluding tractor.

Production requirements for soybean hay. Man labor, horse work, seed and other requirements for soybeans harvested for hay are shown in Table 24. The results obtained on the farms studied and experimental data from the Lexington field indicate that a yield of 4000 pounds per acre of well cured hay may be expected when five pecks of standard hay varieties are sown and good methods are practiced. The seed may be inoculated either with soil or a commercial culture. All the land devoted to the production of soybeans is broken. Approximately eight hours of man labor and 20 hours of horse work per acre are required in preparing the seed bed and planting, and 10 man hours and 10 horse hours per acre in harvesting. A few farmers in the area plant soybeans in rows and cultivate. When this is done about two man hours and two horse hours per acre should be added to the above estimates.

Since practically all the soybeans sown in the area are harvested for hay the best results are obtained from such varieties as produce fine-stemmed plants. Varieties most used are Laredo, Wilson, Haberlandt, Virginia, and Lexington.

Relation of soybean hay to other enterprises. Soybeans are grown largely as an emergency hay crop thruout the bluegrass region and may well be used while a liming program is being put into effect. Usually they are seeded after corn has been planted. Seedbed preparation competes with the same operations for corn and tobacco, and planting conflicts with transplanting tobacco and



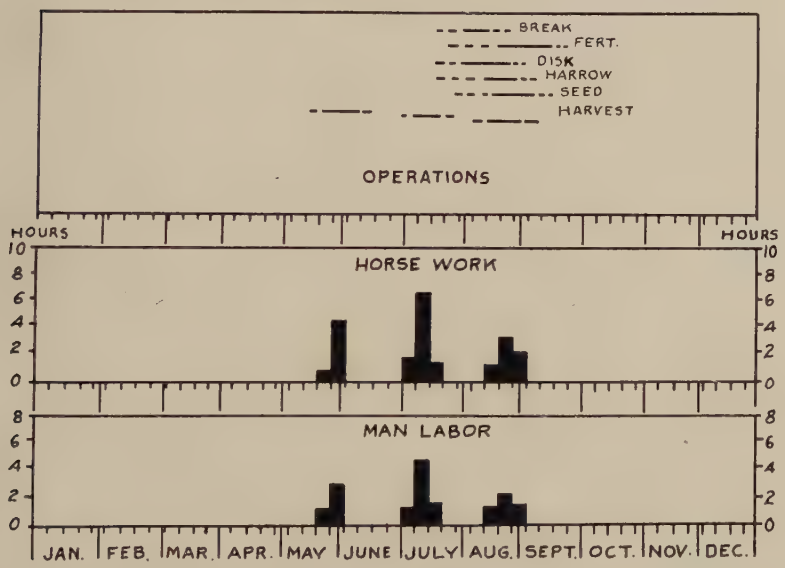


FIGURE 12 (Upper). Soybean hay. Seasonal distribution of man labor and horse work and periods of important operations (see explanation under Figure 5).

FIGURE 13 (Lower). Alfalfa hay. Seasonal distribution of man labor and horse work, and periods of important operations (see explanation under Figure 5).

early cultivation of corn. The harvesting period for soybeans comes at about the same time as cutting and housing tobacco. Altho the periods for both planting and harvesting differ on different farms these operations usually come at busy seasons. Because of these striking conflicts with other crops, the large amounts of man labor and horse work required, and the high cost of seed, soybean hay is an expensive hay crop.

ALFALFA

Alfalfa has been grown in central Kentucky for many years. In the nine central counties 3100 acres were harvested in 1919, whereas, in 1924, 4500 acres were harvested, an increase in acreage of more than 40 percent in five years. Part of the alfalfa is seeded in the spring and part in late summer. Much of that seeded in the spring is seeded with oats as a nurse crop. Practically all the land in the inner bluegrass counties and, to a large extent, the farms in the outer bluegrass counties is limed for alfalfa. Commercial cultures are generally used to inoculate the seed, tho occasionally soil from an old alfalfa field is used. Practices in putting up alfalfa hay are practically the same as for other hay crops.

Man labor, horse work, and seed used for alfalfa hay. These factors in the production of alfalfa hay are shown in Table 25. Labor for spreading limestone was charged but not that for hauling. On the farms for which detailed data were obtained for one or more years the yields ranged from 3200 to 5600 pounds per acre. Man labor used in harvesting ranged from 14 to 28 hours per acre and the horse work, from 16 to 40 hours. Man labor to prepare the seed bed and sow the seed ranged from 6 to 21 hours per acre and the horse work, from 12 to 51 hours. On two of the farms a tractor was used in addition to the teams.

On Farm 21 an average yield of 5600 pounds was obtained during the two years for which data were available. The alfalfa was grown on a thoroly prepared seed bed well limed. The seed were inoculated and sown in the fall at the rate of 21.2 pounds per acre. The first season the alfalfa was cut three times and the second, four times. On Farm 6, from which a yield of 3200 pounds per acre was obtained, the alfalfa was seeded with oats in the spring on land

Table 25. Alfalfa hay. Man labor, horse work and materials used and yield per acre. Route farms, 1921 to 1929, inclusive.

Farm number	Number of years covered	Average area of crop	Yield	Harvesting		Seeding				
				Man labor	Horse work	Man labor	Horse work	Tractor work	Seed	Limestone
		acres	tons	hrs.	hrs.	hrs.	hrs.	hrs.	lbs.	tons
21	2	4.3	2.8	28.3	39.8	21.0	50.6	—	21.2	4.2
1	2	13.4	2.3	16.2	20.8	12.8	18.8	—	15.8	4.0
6	1	4.5	1.6	14.2	16.4	14.2	22.2	—	20.0	5.6
22	1	9.8[1]	—[3]	—[3]	—[3]	16.2	16.4	3.2	20.0	2.0
7	1	19.4[2]	—[3]	—[3]	—[3]	5.5	11.7	1.1	17.3	2.2
Average		9.9	2.2	17.7	23.0	12.3	21.1	1.0	18.1	3.1

1 Not plowed, land disked. 2 Seven and one-half acres disked only, 11.9 acres broken. 3 Data not available for yield, man labor and horse work for harvesting.

which had received an application of 5.6 tons of limestone per acre. The main reason for the low yield was that the third cutting, after being mowed, was ruined by rain before it could be raked and hauled to the barn.

Production requirements for alfalfa hay. Man labor, horse work, seed and other requirements for alfalfa are shown in Table 26. The results obtained on the farms studied and experimental data from the Lexington field indicate that a yield of 5000 pounds per acre of well-cured hay may be expected when 15 pounds of seed are sown and good methods are practiced. Approximately 18 hours of man labor and 30 hours of horse work per acre are required in preparing the seed bed and seeding, 18 man hours and 24 horse hours per acre in harvesting.

Table 26. Alfalfa hay. Production requirements per acre prior to harvest. Spring seeding.

Kind	Amount
Man labor, hours	18
Horse work, hours	30
Limestone, tons	4
Seed, pounds	15
Inoculation,[1]	
Equipment expense, dollars[2]	1.05

1 Commercial cultures are reliable and are most convenient for inoculation; inoculated soil may be used. 2 Both regular and special equipment, excluding tractor.

Unless previously inoculated, all central Kentucky land should be inoculated for alfalfa. Imperfect inoculation is the most common cause for poor stands which result in failure or low yield. Since alfalfa requires neutral soil and most of the land in the region is somewhat acid, it usually is necessary to apply limestone. A sufficent application for alfalfa, in this area, usually is three tons of ground limestone to the acre.

Table 27. Alfalfa hay. Production requirements for harvesting, per acre. Assumed yield, 3 cuttings, 5000 pounds.

Kind	Amount
Man labor, hours	18
Horse work, hours	24
Equipment expense, cents[1]	84

1 Both regular and special equipment, excluding tractor.

Relation of alfalfa to other enterprises. The relation of seeding alfalfa to other enterprises differs according to whether it is sown in the spring or summer. Preparation of the seed bed in summer comes after the small grain has been cut but conflicts with topping, suckering, worming, and spraying tobacco. Spring preparation and seeding come at a busy time when the preparation of land for corn, tobacco, spring oats, and soybeans should be under way. Harvesting differs from seeding in its relation to other enterprises. The first cutting of alfalfa usually is made from May to June and often conflicts with transplanting tobacco, cultivating corn and seeding soybeans. The second cutting is made in July, usually after wheat, clover and mixed hay have been harvested. It comes about the same time as harvesting oats and timothy hay and conflicts with cultural operations of tobacco. The third cutting usually is made in September and conflicts with cutting and housing tobacco.

Normally a larger yield of alfalfa is obtained from a given acreage than of any other hay crop. Alfalfa also lends itself to a better distribution of labor than the other hay crops. Practically all the alfalfa produced in the area is used for feed. A small acreage of alfalfa on well-drained land usually is profitable on a farm on which dairy cattle and sheep are kept.

RED CLOVER

In central Kentucky red clover is an important source of hay. Good rotations in the area generally include clover either for pasture or hay.

Man labor, horse work, and seed used for clover. Man labor and seed used in seeding and the man labor and horse work used in harvesting clover hay are shown in Table 28. Yield ranged from 1200 to 3000 pounds per acre. The chief factors influencing yield are, the natural fertility of the soil, the stand obtained, the extent to which the crop was pastured previous to cutting, and to the rotation followed. Clover failures are becoming quite common in the region. Acidity of the soil, excessive freezing and thawing in winter, drouth, and the use of varieties not adapted to the conditions are the factors largely responsible for these failures.

Table 28. Clover hay. Man labor, horse work, and seed used and yields per acre. Route farms, 1921 to 1929, inclusive.

Farm number	Number of years covered	Average area of crop	Yield	Seeding			Clipping		Harvesting			Total		
				Seed	Man labor	Horse work	Man labor	Horse work	Man labor	Horse work	Tractor hours	Man labor	Horse work	Tractor hours
		acres	lbs.	lbs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
									Hauled in loose					
12	1	11.6	3000	7.3	.8	—	—	—	11.3	13.3	—	12.1	13.3	—
10	1	20.4	2600	7.6	.4	.2	.6	1.1	11.5	14.8	—	12.5	16.1	—
3	1	21.0	2000	8.5	.3	—	—	—	6.3	4.5	—	6.6	4.5	—
13	1	18.8	2000	8.0	.4	—	—	—	12.7	12.8	—	13.1	12.8	—
26	1	18.7	1800	6.4	.4	—	—	—	6.6	5.1	—	7.0	5.1	—
9	4	15.7	1800	5.5	.4	1.3	.4	.8	8.2	8.9	—	9.0	11.0	—
4	2	13.5	1800	8.0	.8	—	—	—	7.2	11.3	—	8.0	11.3	—
23	1	20.4	1400	9.0	.5	—	—	—	5.4	9.4	—	5.9	9.4	—
Average		16.4	2000	7.1	.5	.1	.2	.4	8.4	9.7	—	9.1	10.2	—
									Baled in field					
1	1	20.0	4000	7.2	.6	—	2.1	4.2	12.9	13.3	.2	21.0	17.5	.2
7	1	4.6	1600	6.7	1.1	—	—	—	5.5	3.3	—	6.6	3.3	.2
Average		12.3	3600	7.2	.7	—	1.7	3.4	11.5	11.4	.2	13.9	14.8	.2

The average yield of clover was one-third larger than that of timothy, on the same farms. On these farms the average yield of clover was 2160 pounds per acre while the average yield of timothy was 1540 pounds.

Man labor used in seeding ranged from less than one hour to almost three hours[1] per acre and the horse work ranged from less than one to six hours[2] per acre. The seed used ranged from 6 to 28 pounds per acre. The man labor used in harvesting ranged from 5 to 13 hours per acre and the horse work, from 5 to 15 hours. The differences were largely due to yield, the method employed in harvesting, the size and efficiency of the crew, and the distance from field to barn. Since clover is more difficult to cure than timothy, the labor requirements are usually higher.

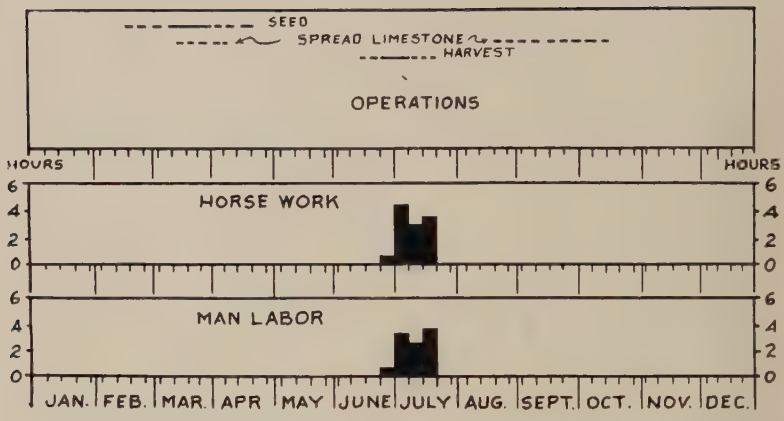
Farm 13 used the largest amount of man labor and horse work in putting up clover hay. The yield was 2000 pounds, the same as the average of eight farms. The hay was cut, raked, stacked and later baled from the stack. The work of stacking accounts for the larger amount of man labor required.

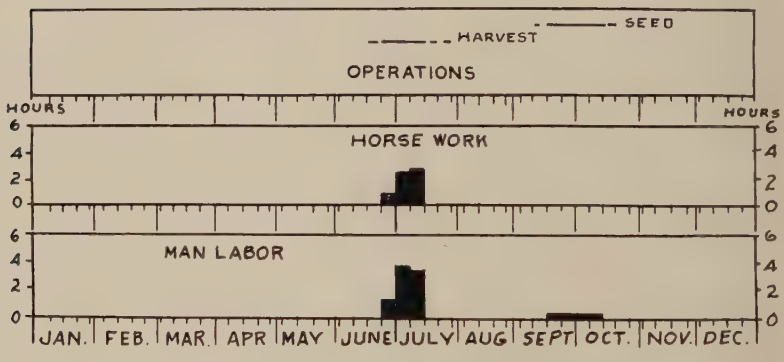
Table 29. Red clover hay. Production requirements per acre. Assumed yield 3000 pounds.

Kind	Amount
Man labor, hours	10
Horse work, hours	10
Limestone, tons	2
Seed, pounds	8
Equipment expense, cents	35

Production requirements for clover. Man labor, horse work and seed requirements for clover are shown in Table 29. The data included in this study, together with other information indicate that a yield of 3000 pounds per acre may be expected. Usually clover is seeded in early spring, by hand, in one of the small grains. No seed bed preparation is necessary and less than an hour of man labor per acre is required, for seeding. Many farmers clip the young clover and for this operation, approximately one man hour and two horse hours are required. Eight to 10 pounds of seed per

1 Man labor includes clipping on four of the farms.
2 Horse work includes clipping on four of the farms.





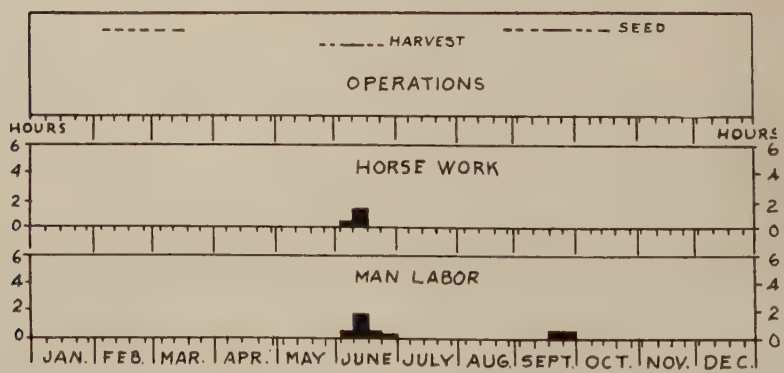


FIGURE 14 (Upper). Red clover hay. Seasonal distribution of man labor and horse work and periods of important operations (see explanation under Figure 5).

FIGURE 15 (Middle). Timothy hay. Seasonal distribution of man labor and horse work and periods of important operations (see explanation under Figure 5).

FIGURE 16 (Lower). Bluegrass seed. Seasonal distribution of man labor and horse work and periods of important operations (see explanation under Figure 5).

acre usually ensures an adequate stand. To harvest a yield of 3000 pounds per acre about nine hours of man labor and 10 hours of horse work per acre are required.

Relation of clover to other enterprises. In relation to other crops, greater benefit is derived from clover when it is used as a pasture crop than when it is cut for hay. However, soil fertility can be well maintained by cutting for hay provided the crop residues and manure are returned to the land. Unlike some of the other hay crops, clover is usually cut for hay only one year. On most farms it also serves as a nurse crop for bluegrass. Unlike soybeans, clover does not require large amounts of man labor and horse work in the spring and does not conflict with the seed-bed preparation and seeding of corn or the transplanting of tobacco. The harvesting of clover, like that of other hay crops, must be done in a comparatively short period. It comes at a busy season, about the last of June or early in July, about the same time as harvesting rye and orchard grass for seed, and interferes with the cultural operations of corn and tobacco.

TIMOTHY

Timothy hay is very desirable for horses. Formerly there was a relatively active market demand for high-quality timothy hay by those engaged in the production of the fine horses but the growing practice of bringing timothy hay from other areas has limited the outlet for that produced locally. Much of the timothy cut in the area was seeded with clover for mixed hay. One or more crops of timothy were harvested on about half the farms studied.

The average yield of timothy hay was only two-thirds as large as the average yield of clover hay on the farms where both timothy and clover were grown; 1540 pounds and 2160 pounds, respectively. The timothy seed used ranged from 8 to 11 pounds per acre.

Man labor, horse work, and seed used. The man labor and seed used in seeding and the man labor and horse work used in harvesting timothy hay are shown in Table 30. Yields ranged from 1000 to 3200 pounds per acre. The chief factors influencing yield were the natural fertility of the soil, amount of seed sown, and the rotation followed.

Table 30. Timothy. Man labor, horse work and seed used and yield per acre. Route farms, 1921-1929, inclusive.

Farm number	Number of years covered	Average area of crop	Seed	Yield	Seeding		Harvesting			Total		
					Man labor	Horse work	Man labor	Horse work	Tractor hours	Man labor	Horse work	Tractor hours
		acres	lbs.	lbs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
									Put up loose			
13	1	15.3	—[1]	3200	—[1]	—[1]	6.5	8.4	—	6.5	8.4	—
17	1	12.7	—[1]	2200	—[1]	—[1]	9.8	9.4	—	9.8	9.4	—
10	1	12.4	9.0	2000	.5	—	4.8	6.6	—	5.3	6.6	—
11	1	19.2	2.8	2000	1.3	—	6.6	6.1	—	7.9	6.1	—
2	1	1.0	—[1]	2000	—[1]	—[1]	9.0	12.0	—	9.0	12.0	—
6	1	51.0	22.1	1680	.8	—	6.1	6.5	—	6.9	6.5	—
25	1	20.0	—[1]	1600	—[1]	—[1]	12.0	13.0	—	12.0	13.0	—
5	1	36.7	—[1]	1200	—[1]	—[1]	4.2	5.7	—	4.2	5.7	—
8	1	22.5	—[1]	1200	—[1]	—[1]	5.2	6.1	—	5.2	6.1	—
9	2	12.1	—[1]	1200	—[1]	—[1]	7.9	8.3	—	7.9	8.3	—
4	2	22.4	—[1]	1000	—[1]	—[1]	3.2	4.5	—	3.2	4.5	—
Average		20.0	15.6[2]	1600	.9[2]	—	6.1	6.9	—	7.0	6.9	—
									Baled in field			
1	2	38.2	5.9	2800	—[1]	—[1]	8.2	6.7	—	8.2	6.7	—
12	1	15.6	—[1]	1200	—[1]	—[1]	7.5	3.8	—	7.5	3.8	—
7	4	16.6	—[1]	1200	—[1]	—[1]	6.0	5.4	.3	6.0	5.4	.3
Average		19.8	5.9[2]	2000	—	—	7.2	5.8	.1	7.2	5.8	.1

1 Old seeding and no seed or labor for seeding reported. 2 Only farms reporting included in average.

The man labor used in harvesting ranged from 4 to 10 hours per acre and the horse work ranged from 5 to 13 hours per acre, the differences being largely due to the methods employed in harvesting, the efficiency and size of crew and the distance from field to barn.

The small acreage was responsible for the large labor requirements on Farm 2. On Farm 25 labor requirements were large because the 20 acres harvested were made up of only the best parts of 46.5 acres cut over. Farm 4 which produced the smallest yield used the smallest amount of both man labor and horse work in putting up timothy hay. The labor was handled efficiently in harvesting hay as in all other operations on the farm. The fields were relatively large and well shaped, and the barns were conveniently located.

Production requirements. Man labor, horse work and seed requirements for timothy hay are shown in Table 31. The data in this study indicate that a yield of 2500 pounds per acre may be expected for the requirements shown. Usually timothy is seeded along with one of the small grains, and little additional labor is required. With an average sized crew and a normal amount of equipment, approximately seven man hours and seven horse hours per acre will be required to harvest.

Table 31. Timothy hay. Production requirements per acre. Assumed yield 2500 pounds.

Kind	Amount
Man labor, hours	7
Horse work, hours	7
Seed, pounds	9
Equipment expense, cents	35

Relation of timothy hay to other enterprises. Under favorable conditions timothy can be cut for several years without reseeding and may also furnish some aftermath pasture.

Since no seed-bed preparation is necessary and the seed is usually sown with one of the small grains, the conflicts would be the same as for the crop with which the timothy is sown. The heaviest man labor and horse work requirements for timothy are in har-

vesting, about the middle of July. It comes after the harvesting of both clover and mixed hay and at about the same time as the harvesting of oats, the second cutting of alfalfa, and some of the operations in tobacco culture.

BLUEGRASS

Kentucky bluegrass is so extensively grown in Central Kentucky that the area is generally known as the Bluegrass Region. Altho bluegrass is primarily a pasture crop, production of seed is an important enterprise on many of the larger farms. Yields of the seed sold while green ranged from 8 to 12 bushels per acre and the seed sold when cured ranged from 4 to 10 bushels per acre.

Man labor and horse work used for bluegrass seed. These items in the production of bluegrass seed are shown in Table 32, arranged in order of yield, beginning with the highest. On all farms the data were obtained for only one year. The seed harvested on Farms 28, 31, 29, and 30 was sold while green; that from all other farms was cured before it was sold. There were wide differences in yield from farm to farm, due largely to differences in fertility of the soil, suitability of the locality to the production of bluegrass seed, stand of grass and degree to which it had been grazed.

When bluegrass seed is marketed green, the large amount of man labor necessary in curing is saved. On some farms where the seed is cured and large acreages are harvested, it was found that much man labor could be saved by using a hay tedder to turn the seed in curing.

Requirements for bluegrass seed. Man labor, horse work and seed requirements for bluegrass seed are shown in Table 33. The data in this study indicate that an average yield of eight bushels of cured seed per acre may be expected from the requirements shown. Nearly always bluegrass is seeded with one of the small grains, and is sown in the fall, separately, by hand. Clover often is seeded in the same field the following spring. No seed-bed preparation is necessary and the seeding usually requires less than one hour per acre. The amount of seed sown is about 14 pounds per acre. Should the seed be harvested with an automatic stripper, two hours of man labor and two hours of horse work are required.

Table 32. Bluegrass seed. Man labor and horse work used in harvesting and marketing, per acre. Route farms, 1927.

Farm number	Number of years covered	Average area of crop	Strip, haul, cure and sack		Market		Total		Yield
			Man labor	Horse work	Man labor	Horse work	Man labor	Horse work	
		acres	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	bus.
28	1	25	1.3	1.4	1.2	—[3]	1.5	1.4	12.4[1]
31	1	20	2.3	1.2	—[5]	—[5]	2.3	1.2	11.2[1]
29	1	10	2.0	2.0	.1	—[3]	2.1	2.0	10.0[1]
30	1	300	2.3	1.6	—[4]	—[4]	2.3	1.6	8.0[1]
37	1	350	4.4	2.2	.1	—[3]	4.5	2.2	10.0
34	1	275	2.6	2.4	—[6]	—[6]	2.6	2.4	8.3
32	1	500	2.0	1.5	—[6]	—[6]	2.0	1.5	7.2
33	1	300	2.5	2.4	—[6]	—[6]	2.5	2.4	7.2
36	1	414	3.3	1.2	.1	—[3]	3.4	1.2	6.9
35	1	40	3.1	1.1	.2	.3	3.3	1.4	3.8
Average[1]		88	2.2	1.6	—[7]	—[7]	2.2	1.6	8.6
Average[2]		313	2.9	1.8	.2	.3	3.1	2.1	7.7

1 Sold green (uncured). 2 Cured before sold. 3 Truck used. 4 Buyer hauled seed. 5 Kept seed for own use. 6 Seed hauled by contract. 7 Only farms using both man labor and horse work included in average.

To cure the seed on the farm requires about one additional hour of man labor.

Table 33. Bluegrass seed. Production requirements per acre. Assumed yield, 8 bushels, rough cured.

Kind	Amount
Man labor, hours	3
Horse work, hours	2
Seed, bushels, cleaned seed	1
Equipment expense, cents	10
Special equipment expense, cents	90

Relation of bluegrass to other enterprises. A very close relationship exists between bluegrass and other enterprises, both crop and livestock. Bluegrass has a most important function in the rotation not only by supplying pasture and seed but also by holding the soil against erosion and improving its texture and productivity. Tobacco gives better yields and is usually of higher quality after bluegrass sod than after any other crop.

Stripping bluegrass seed comes at a busy time, in late May and early June. The period during which the seed can be harvested lasts only about ten days. If the seed is cured on the farm, labor is required for three weeks. Both stripping and curing conflict with transplanting tobacco, planting soybeans and cultivation of corn and tobacco. Bluegrass is usually seeded with clover in a small grain which serves as a nurse crop.

SHEEP

Sheep are an important source of income on a large proportion of the farms in the Bluegrass Region. The number of sheep in this area has been increasing for the past several years. The comparatively mild winter climate and abundance of pasture favor the production of spring lambs in Central Kentucky; other favorable factors are location with respect to consuming areas of the United States and good marketing facilities. The 57 flocks included in this study averaged 98 ewes, ranging from 15 to 313 ewes per flock (Table 34).

Lamb and wool production. Lamb production from the flocks studied varied from 41 to 107 pounds per ewe, averaging 81 pounds.

Study of these sheep enterprises for the five years, 1932 to 1936, indicates that high lamb production is very closely associated with the profitableness of the flock. The higher-producing flocks such as those on farms numbers 35, 21a, 17, 1a and 25, raised more lambs from each 100 ewes because their ewes were more vigorous due to better care and selection. Better care was indicated by a drenching program and the time spent with the ewes during the lambing period. Better selection was evidenced by a larger percentage of two- to six-year-old ewes and a lower death loss of mature sheep. Better care and vigor of these flocks were further emphasized by smaller death loss of lambs from starving, chilling, and being born weak or dead.

The average amount of wool produced per mature sheep ranged from about 4 pounds to more than 8 pounds, averaging about 6 pounds per head.

Bran and shorts, oats, cottonseed meal, linseed meal and commercial mixed feed were the principal purchased feeds used.

Lamb and wool prices. During the past five years, 1931 to 1936, the farmers cooperating in the study received approximately the same price for their lambs as quoted for choice lambs on the Cincinnati market. The price received for wool was equal to and generally a few cents per pound higher than the average Kentucky farm price (Table 35).

Production and requirements. The data presented in Table 34 together with experimental data showing results when different rations were fed, were used in working out the feed, labor and other requirements for sheep. Requirements per head for three different feed combinations are suggested, all similar to those used by the better farmers in this area. These requirements allow half an acre of good pasture per mature head (Table 36). This includes the use of small-grain pasture, a practice followed by most of these farmers. Normally, in this area, the pasture season extends from late February to the last of December, as experienced by the 57 farmers, an average of 327 days annually.

These requirements provide for feeding legume hay during the period when pasture is not available. The grain requirements allow for a short grain-feed period prior to the lambing season and

Table 34. Sheep. Lamb and wool production with feed, man labor and other costs per mature head per year, 1924 to 1928 and 1932 to 1936. Arranged in order of live weight of lambs produced per ewe, beginning with the highest.

Farm number	Number of years covered	Size of flock[1]	Average production		Concentrates					Roughage				Man labor	Miscellaneous costs[2]
			Lambs	Wool	Corn	Barley	Other small grain	Linseed or C. S. meal	Other mill feed	Legume hay	Other hay	Other roughage	Pasture		
		head	lbs.	lbs.	bus.	bus.	bus.	lbs.	lbs.	lbs.	lbs.	lbs.	days	hours	dollars
35	4	71	107	5.6	.1	—	.5	—	—	108	—	—	355	4.3	.34
21a	3	72	106	8.2	.4	—	.2	6	26	180	—	18	364	4.9	.48
17	2	23	105	4.6	.1	—	—	—	30	247	75	113	344	7.3	—
1a	5	118	101	6.8	.6	.8	2.7	—	15	122	—	17	328	3.8	.44
25	1	106	99	5.7	—	.5	—	—	—	47	66	106	358	5.2	.17
37	5	53	99	5.9	—	—	—	1	8	90	11	4	343	6.5	.44
76	4	64	98	6.2	.9	—	—	—	—	208	—	8	320	3.5	.27
38	5	104	94	4.6	.4	—	—	—	6	157	2	2	320	6.6	.34
33	5	95	93	6.2	.4	.5	—	5	14	118	—	15	345	3.3	.20
43	3	58	92	6.1	.1	—	.3	—	3	211	—	—	208	2.5	.33
55	2	158	91	7.3	—	.4	—	6	45	36	—	10	363	3.0	.18
16a	1	81	91	6.2	—	.6	.5	—	—	111	—	50	366	2.8	.90
4	1	39	91	7.5	1.0	—	—	—	—	—	142	—	306	7.1	.09
26a	5	103	90	5.9	.1	.4	.1	—	15	113	—	16	339	5.0	.25
23a	5	60	90	6.0	—	1.0	—	—	—	130	1	7	313	8.9	.29
75	5	136	89	7.5	.1	—	.3	2	13	156	—	9	290	3.1	.47
31	5	58	88	5.1	—	—	—	1	26	122	—	—	348	4.1	.20
60	1	42	86	5.1	—	—	—	—	94	453	—	—	258	12.4	.65
71	5	134	85	5.1	.8	—	—	1	1	138	—	12	328	3.9	.21
3a	4	52	85	6.9	—	—	—	—	—	22	11	8	364	3.5	.29
73	5	264	85	6.2	.3	—	.2	1	9	246	—	13	323	3.7	.27
20a	3	119	85	5.9	—	—	.5	—	—	98	—	—	364	2.0	.21
22	2	76	85	6.6	.2	2.2	.2	3	98	39	26	115	339	6.8	—
27a	4	20	84	5.7	.4	—	—	—	5	187	—	—	346	6.6	.31
22a	5	71	84	7.1	—	.2	—	—	—	202	46	—	350	5.0	.38
25a	5	110	84	5.6	.3	.3	.2	4	20	118	—	—	343	3.0	.53

17a	4	168	84	5.6	.1	—	—	—	—	74	—	4	344	2.4	.23
70	5	160	84	5.2	1.0	—	.1	4	2	119	—	2	324	6.4	.24
5	1	106	84	5.6	—	1.2	—	—	—	—	28	9	365	3.0	.31
42	5	82	83	4.5	.5	—	.4	—	7	210	—	—	329	3.7	.31
16	1	21	81	4.6	.2	—	—	—	—	—	71	219	290	7.5	.19
23	1	80	81	6.1	—	—	—	—	—	175	37	98[3]	322	3.9	—
3	1	77	81	5.9	.2	—	—	—	12	—	78	188	325	2.9	19
8a	5	38	80	6.0	.3	—	—	—	5	123	—	16	330	4.2	.34
36	5	86	80	4.8	.1	—	—	—	4	44	—	2	333	4.9	.28
30	1	54	79	7.5	.4	—	—	—	—	129	—	—	366	2.4	.32
28	2	103	79	5.9	.2	.1	.2	—	—	156	—	5	366	4.4	.20
44	5	30	79	6.4	.1	—	.1	—	20	206	—	3	317	4.3	.26
10a	5	95	78	6.5	—	.1	—	—	—	70	—	37	342	2.6	.26
54	3	206	78	5.0	.1	—	.1	1	1	148	—	78[3]	332	2.5	.20
15a	1	94	76	6.2	.4	—	—	—	—	64	—	—	366	3.4	.21
13a	5	54	76	4.8	.2	—	—	—	18	74	—	—	340	4.7	.34
7a	5	15	75	6.5	—	—	—	—	—	132	—	6	353	3.2	.31
7	10	39	74	6.0	.2	—	.1	2	15	97	2	36[3]	323	4.3	.34
72	1	67	73	7.4	.3	—	.1	—	3	79	—	15	351	2.8	.40
45	5	313	72	6.4	.6	—	.4	2	2	80	—	3	340	1.9	.22
24a	5	42	72	5.0	—	—	—	2	2	113	2	5	307	3.0	.28
52	5	113	72	5.0	.3	—	—	1	10	92	—	—	335	3.7	.28
9	10	198	72	5.8	.3	.1	.2	1	8	133	1	28[3]	300	2.5	.34
48	1	192	71	5.2	—	—	—	—	10	188	—	84	366	4.3	.42
24	5	36	70	7.6	.3	.3	—	—	1	92	—	—	354	3.4	.31
1	9	95	69	5.8	—	—	.1	—	7	71	27	23[3]	318	2.1	.34
6	10	140	68	5.2	.3	—	.1	—	—	70	11	103	320	2.7	.28
19	1	30	61	3.7	.5	—	.1	—	—	66	138	98	255	6.0	.15
53	4	33	53	5.4	.3	—	—	—	—	165	—	97[3]	319	5.3	.27
12	1	49	47	4.2	—	—	.2	—	—	71	—	631[3]	268	5.4	.04
40	1	29	41	8.2	—	.2	—	—	—	275	—	69	332	7.5	.29
Average		98	81	5.8	.3	.1	.1	1	8	121	5	24[3]	327	3.8	.29

1 Ewes and rams. 2 Veterinary fees, medicine, trucking, shearing, salt and mineral. 3 Silage reduced to dry roughage basis; 3 pounds of silage equivalent to 1 pound of dry roughage.

continuing until the ewes and lambs can be turned on small-grain pasture. Grain for feeding the lambs in addition to that for the ewes was not provided since very few of these farmers followed the practice of creep feeding the lambs.

Table 35. Sheep. Prices of lambs and wool, 1924 to 1936, inclusive.

Year	Lambs, per 100 lbs.		Wool, per pound	
	Cincinnati (Choice)[1]	Cooperating farmers[2]	Average for Kentucky[3]	Cooperating farmers[2]
	dollars	dollars	cents	cents
1924	—[4]	13.03	39	43
1925	—[4]	14.70	42	46
1926	—[4]	14.06	38	40
1927	—[4]	13.79	37	37
1928	15.74	14.22	46	57
1929	14.44	—[4]	41	—[4]
1930	10.04	—[4]	28	—[4]
1931	8.23	—[4]	18	—[4]
1932	6.82	6.70	13	13
1933	7.11	7.59	22	29
1934	8.05	8.10	26	29
1935	8.99	8.56	24	27
1936	10.33	10.47	31	38

1 Average of monthly prices as reported in "Notes on Kentucky Agricultural Situation" prepared by the Department of Markets and Rural Finance of the Kentucky Agricultural Experiment Station. 2 Average price received by farmers included in the study. 3 Average monthly price for Kentucky wool as reported in "Crops and Markets" published by U. S. D. A. 4 Data not available.

Feed combination 1 provides 2 pounds of legume hay per mature head daily and $1\frac{1}{3}$ pound of stover, for 75 days. The grain mixture of corn, bran or shorts and linseed meal allows $\frac{1}{2}$ pound of the mixture daily for 30 days prior to lambing and provides 27 pounds of grain for the ewe after lambing. In the second combination oats are substituted for bran and linseed meal and part of the corn. Additional legume hay instead of stover takes the place of some linseed meal also. The third combinaton differs from the first only in the substitution of oats for bran and shorts.

Relation of sheep to other enterprises. The heaviest man labor requirements for sheep come in the winter feeding period and the lambing season, January to March (Figure 17, page 190). Considerable labor is required thru April and the first half of May for special work such as shearing, docking, castrating and drenching. This labor requirement for sheep fits well into the labor demands

for crops, especially tobacco. A small amount of horse work is required during the winter feeding period and occasionally during the lamb-marketing season.

Table 36. Sheep. Production requirements for an assumed annual production of 90 pounds of lambs and 7 of wool, per mature head.

	Amount per year		
	1 Combination	2 Combination	3 Combination
Feeds:			
Corn, bushels	.5	.25	.25
Oats, bushels	—	.75	.5
Bran and shorts, pounds	10	—	—
Linseed meal, pounds	3	—	3
Legume hay, pounds	150	200	150
Corn stover, pounds	100	—	100
Straw, pounds	50	50	50
Pasture, acres	.5	.5	.5
Labor:			
Man labor, hours	5	5	5
Horse work, hours	1	1	1
Miscellaneous:			
Depreciation, dollars	1.25	1.25	1.25
Shelter and equipment, dollars	.30	.30	.30
Shearing, dollars	.12	.12	.12
Other items, dollars[1]	.15	.15	.15

1 Veterinary fees, medicine, salt and twine.

Sheep are good scavengers and may be used in controlling weeds and "filth" in bluegrass and orchard grass for seed, and in hay crops. Insofar as sheep use roughages that do not have a ready cash market, they furnish a source of cash income from these crops.

Where sheep use feeds that would otherwise be sold off the farm, they aid in maintaining soil fertility. Since they use largely pasture and legume hay, they fit in well with a soil-buildng program. Thus sheep are well adapted to the rolling grass-land areas of the state where farmers are confronted with the problem of making economical use of large amounts of roughage, mostly pasture, and relatively small amounts of grain.

BEEF COWS

Beef production in the Inner Bluegrass Region is from two sources, purchased feeder cattle and the beef-cow herds. For the past several years the number of beef-cow herds has increased in this area. The relatively large acreage of pasture and a mild cli-

mate that makes possible a long pasture season encourages the beef-cow herd enterprise. In addition to the good pasturage, a considerable amount of roughage such as corn stover and straw, having little or no market value, is produced. The beef-cow herd affords a means of obtaining a cash income from such unmarketable roughages.

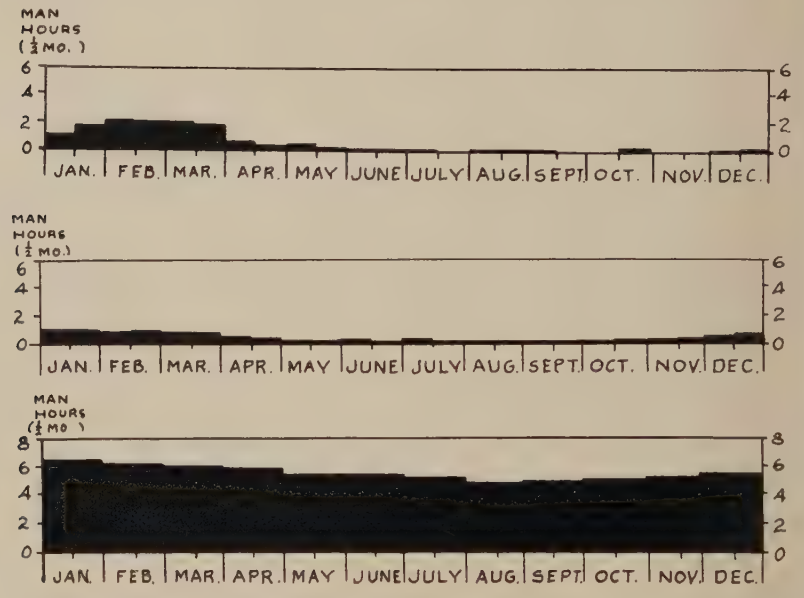


FIGURE 17 (Upper). Sheep. Seasonal distribution of man labor for 5 mature sheep.
FIGURE 18 (Middle). Beef cows. Seasonal distribution of man labor for one cow.
FIGURE 19 (Lower). Dairy cows. Seasonal distribution of man labor for one cow producing 6000 pounds of milk annually.

Farmers with beef-cow herds raise fat calves or feeder calves. Occasionally a few veal calves may be sold but, generally, this is an unprofitable practice. The cow herd is usually fed about the same in raising fat calves as in raising feeder calves. Fat calves, however, are usually fed grain while nursing, in order to have them ready for market by weaning time. The practice of selling the calves by weaning time lessens the loss of milk fat. Feeder calves are usually carried thru the winter on roughage with a small amount of grain and fattened on pasture the following year. Some farmers finish these cattle on grain during the last 15 to 30 days prior to marketing.

Table 37. Beef cows. Feed, man labor, horse work, other costs, and production per mature head, per year, Arranged in order of beef production per mature head, beginning with the largest.

Farm number	Number of years covered	Size of herd	Average production		Concentrates			Roughage				Pasture	Man labor	Horse work	Miscellaneous costs[2]
			Calves[1]	Milk	Corn	Cotton seed meal	Other mill feed	Legume hay	Other hay	Stover	Straw				
		head	lbs.	lbs.	bus.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	days	hours	hours	dollars
79	5	10	555	131	14.3	—	—	1512	64	2078	—	237	17.7	—	.12
36	1	9	520	—	3.8	—	—	2690	—	1648	—	285	16.7	—	.22
35	2	17	473	—	.3	—	—	1789	—	276	—	323	9.3	—	1.20
33	1	10	429	—	—	—	—	2226	—	1106	2020	269	8.8	—	.10
73	4	25	427	—	.3	40	—	246	—	2194	136	274	10.3	4.7	.33
13a	4	28	404	—	2.0	—	—	457	369	2809	35	272	8.4	—	.30
9	2	14	393	—	.7	—	—	70	255[3]	165	146	286	10.1	—	1.21
76	5	33	376	509	1.3	15	—	513	247	1934	312	206	13.6	4.1	.24
74	1	13	345	—	4.4	31	—	154	—	1667	1026	303	4.0	—	.14
81	4	22	344	181	3.6	—	12	1030	816	1508	140	208	13.1	.4	.23
26a	3	17	332	497	2.1	—	335	140	—	300	677	214	16.3	—	.17
78	5	27	326	39	—	4	—	185	—	1465	396	256	10.6	5.9	.20
7	3	14	296	—	.4	1	—	818	24	1771	25	253	7.3	.1	.37
80	1	44	287	44	1.8	—	—	—	—	2680	484	260	11.7	—	.63
45	1	21	271	—	—	—	—	442	441[3]	—	—	274	8.6	—	.21
Average		22	425	154	2.1	8	20	572	193[3]	1733	253	248	12.2	2.2	.32

1 Inventory weight of calves as of January first. 2 Veterinary fees, medicine, salt and mineral. 3 Silage reduced to dry roughage basis—3 pounds of silage equivalent to 1 pound of dry roughage.

Feed, man labor, horse work and other costs for beef cows. The 15 herds included in this study produced an average of 425 pounds of calf per mature head, per year (Table 37). Production ranged from 271 pounds to 555 pounds per mature head. The variation in production was influenced by the number of calves raised, time of calving, and amount of grain fed the calves. On farm number 79, approximately 9 calves were raised for each 10 mature head in the breeding herd. Most of the calves were dropped in February, March, and April and were fed grain from the time they would eat it until they were sold. These calves averaged 634 pounds per head when sold in October.

Farm number 78 shows the result of May, June and July calves that were not grain fed while nursing. This herd raised an average of 9 calves for each 10 mature head. These calves were carried thru the winter on roughage and a small amount of grain. The following spring and summer they were run on pasture and then grain fed during August, September, and October. These cattle were sold in October as yearlings weighing approximately 700 pounds each. Summer calving made possible the avoidance of some grain feeding to the cows during the winter but the calves when fattened as yearlings were sold lighter than if they had been born earlier in the year.

Farm number 76 shows the results of February, March, April and May calves. The cows were fed some grain late in the winter to have them in good condition for calving. The calves ran with the cows during the summer and fall and after weaning were carried thru the winter on roughage and some grain. The following spring they were put on good pasture from which they were sold in October as 800 to 900 pound grass fat cattle.

Production and requirements for beef cows producing fat calves. The data presented in Table 37 together with experimental data showing results when different rations were fed were used in working out the expected normal feed, labor and other requirements for beef cows. The grain requirement for producing fat calves is greater than for raising feeder calves. This additional grain is included with the amounts shown for each mature head (Table 38).

Three feed combinations are presented in order to provide a choice that best fits the feeds produced on the farm.

Table 38. Beef cows. Production requirements per mature head per year, in producing fat calves, including requirements for herd bull and for calves to weaning age. Assumed annual production, 500 pounds of fat calf and 100 pounds of cull cow.[1]

	Combination 1	Combination 2	Combination 3
Feed:[2]			
Corn, bushels	10	12	10
Cottonseed meal, pounds	10	—	50
Legume hay, pounds	2000	2750	1000
Corn stover, pounds	2000	1000	2500
Straw, pounds	500	500	1000
Pasture, acres	2.5	2.5	2.5
Labor:			
Man labor, hours	15	15	15
Horse work, hours	2	2	2
Miscellaneous:			
Shelter and equipment expense, dollars	1.75	1.75	1.75
Other items, dollars[3]	.35	.35	.35

1 With 95 percent calf crop raised, sale of fat calves weighing 600 pounds, and replacing one-ninth of the cows annually, there would be an average of 500 pounds of calf and 100 pounds of cull cow for sale annually per mature head. 2 Includes the grain fed to calves while nursing. 3 Veterinary fees, medicine and salt. If a herd bull is not kept the amount of service fees should be added to the cost.

All combinations suggest the maximum use of good pasture which, according to the experience of the 15 farmers, Table 37, should furnish from 240 to 275 days of pasture per year. For the remainder of the year when the pasture is of little or no value for beef cattle the combination provides a small amount of grain with an abundance of roughage for the cows and herd bull. The primary difference in the three combinations is in the amounts and kinds of roughage suggested, corn stover and straw being substituted for legume hay. The concentrates suggested include feeds for the nursing calves and a small amount for the cows late in the winter. This late winter grain feed for the cows may be used where the calves are dropped in February, March and April. The production includes the maintenance of the cow herd and the sale of fat calves weighing approximately 600 pounds. To take care of death loss and the loss on the cows that should be culled, it is assumed that one-ninth of the cows will be replaced annually. With this plan

500 pounds of fat calf and 100 pounds of cull cow are available f sale each year.

Production and requirements for beef cows raising feed calves. The experience of the farmers cooperating in this stu and experimental data showing results when different rations we fed have been used in working out the feed, labor and other r quirements for beef cows raising feeder calves. The feed combin tions include the maximum use of roughage and pasture. The di ferences in the feed combination are largely the substitution legume hay for corn stover, corn and cottonseed meal (Table 3 Feeds are not provided for the calves since they will not be fatten for market in the same year.

Table 39. Beef cows. Production requirements per mature head per ye in raising feeder calves, including requirements for herd bull. Assumed pr duction 375 pounds of feeder calf and 100 pounds of cull cow.

	Combination 1	Combination 2	Combination 3
Feed:			
Corn, bushels	1	—	—
Cottonseed meal, pounds	50	—	—
Straw, pounds	500	1000	500
Corn stover, pounds	4000	2000	3000
Legume hay, pounds	—	1800	1200
Pasture, acres	2.5	2.5	2.5
Labor:			
Man labor, hours	10	10	10
Horse work, hours	2	2	2
Miscellaneous:			
Shelter and equipment expense, dollars	1.75	1.75	1.75
Other items, dollars[1]	.35	.35	.35

1 With 95 percent calf crop raised, raising feeder calves weighing 450 pounds each, and replacing one-ninth of the cows annually, there will be an average of 375 pounds of feeder calf for each mature head. 2 Veterinary fees, medicine and salt. If a herd bull is not kept these costs should be increased to include the service fees.

The production plan provides for raising heifers for herd re placement and raising feeder calves averaging 450 pounds. As in the herd producing fat calves, it is assumed that one-ninth of the mature herd is replaced each year. This plan provides an average of 375 pounds of feeder calf and 100 pounds of cull cow annually for each mature head.

Production requirements for beef breeding heifers. In providing

for the replacement of the beef breeding herd, about one-ninth as many heifers will be needed as there are mature head in the herd. The two feed combinations provide the maximum use of roughages and pasture for raising breeding heifers (Table 40). From 240 to 275 days of pasture are expected. Where a surplus of pasture exists on the farm because of a luxuriant growth during favorable weather this pasture period may be extended later into the fall. These requirements are suggested for the beef heifer from one to two years old. The first-year feed requirements are included with those for the cow herd.

Table 40. Beef breeding heifers. Production requirements per head, per year, for beef heifers 1 to 2 years old.

	Combination 1	Combination 2
Feed:		
Corn, bushels	2	—
Legume hay, pounds	1000	1500
Corn stover, pounds	1750	1000
Straw, pounds	—	500
Pasture, acres	2	2
Labor:		
Man labor, hours	10	10
Horse work, hours	2	2
Miscellaneous:		
Shelter and equipment expense, dollars	.75	.75
Other items, dollars[1]	.25	.25

1 Veterinary fees, medicine and salt.

Relation of beef cows to other enterprises. The average annual labor requirement was 12 man hours per mature head for the 15 herds (Table 37). This labor requirement is heaviest during December, January, February, March and April (Figure 18, page 190). Beef cattle thus offer a means of earning an income from labor that may not otherwise be fully employed. They do not compete seriously with other enterprises for man labor since the total labor requirement for beef cattle is comparatively small.

FEEDER CATTLE

Feeder cattle are an important livestock enterprise on many farms in the Central Bluegrass region. The number of feeder cattle in this area varies greatly from year to year because this class of

beef cattle makes use of the surplus roughages and pasture. Most of the feeder cattle weigh from 800 to 1000 pounds when fattened, while some farmers fatten heavy feeder cattle weighing 1200 to 1400 pounds. Feeding practices vary from all-grass-feeding to occasional dry-lot feeding. Grass feeding predominates. Some farmers follow the practice of feeding grain for the last few weeks prior to marketing. Most of the feeder cattle are bought in the fall or spring. A common practice is to buy feeders in September, October or November in order to feed on pasture and roughage with a small amount of grain until spring. In May these cattle are turned on pasture to fatten for sale in summer or fall.

Production requirements for light feeder cattle. The following production requirements are based upon the experience of successful farmers and experimental data showing the results when different rations were used in fattening feeder cattle. Light feeder cattle make up the greater part of the cattle fattened in the Central Bluegrass region. Because of the great differences in feeding practices four feed combinations are suggested (Table 41).

Table 41. Light feeder cattle. Production requirements per hundred pounds of gain.[1]

	Combination 1	Combination 2	Combination 3	Combination 4
Feed:				
Corn, bushels	—	7.5	5	11
Cottonseed meal, pounds	—	10	—	25
Legume hay, pounds	—	—	200	275
Corn stover, pounds	—	—	800	—
Straw, pounds	—	—	—	200
Pasture, acres	.8	.7	.7	—
Labor:				
Man labor, hours	1.5	2	2.5	3
Miscellaneous:				
Shelter and equipment expense, dollars	.20	.20	.20	.20
Other items, dollars[2]	.02	.02	.02	.02

1 To determine the amounts per head multiply the hundred weight of expected gain by the quantities given in the combination that is chosen. 2 Veterinary fees, salt and medicine.

Combination 1 provides 175 to 180 days of pasture for cattle purchased in late April or May and sold in late October or November.

Combination 2 provides feed for cattle purchased in late April or May. Corn and cottonseed meal are suggested, to provide a concentrate feeding period for finishing the cattle. This provides 10 to 15 pounds of shelled corn per head daily for about the last 100 days before marketing.

Combination 3 provides feed for cattle purchased in the fall. The legume hay and corn stover with a small amount of corn are to keep the cattle in a thrifty condition thru the winter. The remainder of the corn is to be fed during the last 15 to 30 days prior to the sale in October or November. This allows 3 to 5 pounds of corn per head daily during the winter and an average of 10 pounds of corn per head daily for a 30-day feed period before marketing.

Combination 4 provides for the winter fattening of steers purchased in the fall and fed for 100 to 150 days. It provides 10 to 12 pounds of concentrates and 7 to 10 pounds of legume hay and straw daily.

DAIRY COWS

Dairying in the Inner Bluegrass Area has increased during the last three or four decades. From 1920 to 1930 the production of milk in the Inner Bluegrass Area approximately doubled. Since 1930 the production has increased slightly. Dairy cattle require large amounts of pasture and hay crops and considerable amounts of concentrates. Good pastures, legume hay and most of the concentrates grown on the farm are essential in the economical production of milk and butterfat.

Feed, man labor, and materials used for dairy cows. The annual production of milk per cow in this study of 16 herds[1] ranged from 3252 to 9719 pounds and averaged 5964 pounds (Table 42). High production was the result of years of careful work on the part of the dairymen in improving their herds thru breeding, feeding, and disease control. The better dairymen culled their cows according to known production and replaced them with carefully selected heifers raised from their best cows.

In general, high production per cow is more economical than

1 In Bourbon, Clark, Fayette, Harrison and Montgomery Counties.

Table 42. Dairy cows. Feed, man labor, other costs and milk or butterfat produced per cow per year, 1924-28 and 1931-36[1]. Arranged in order of pounds of milk per cow.

Farm number	Number of years covered	Size of herd	Average production		Concentrates					Roughage			Pasture	Man labor	Miscellaneous costs[2]
			Milk or	Butterfat	Corn	Barley	Bran	Cottonseed meal	Other concentrates	Legume hay	Silage	Other roughage			
		head	lbs.	lbs.	bus.	bus.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	days	hrs.	dollars
98	4	16	9719	348	18.3	18.9	300	403	242	1935	—	2647	207	138	1.96
99	1	20	7779	287	6.7	—	—	—	563	2591	3220	1138	227	125	1.73
100	2	17	6826	299	20.1	2.0	568	381	318	2190[4]	—	614	218	109	.30
101	1	20	6796	361	—	—	310	—	2668	2062	5111	1100	211	174	3.44
102	1	19	6490	362	18.3	—	41	417	337	1039	3319	622	242	138	1.77
52	2	23	6104	292	2.4	—	33	—	1506	814	3887	—	211	125	.19
53	3	11	5835	322	7.9	17.3	425	188	102	1394	2767	1262	222	136	.79
82	2	26	5672	289	7.5	14.7	293	117	488	2087[4]	2814	77	216	201	.48
103	1	7	5552	295	28.3	—	480	209	707	2802	—	299	260	229	3.19
83	2	26	5272	257	9.5	8.7	281	39	564	2053[4]	2762	482	228	119	1.77
2	4	20	5097	—[3]	13.2	—	380	123	199	3057	6421	1110	201	119	1.68
104	1	14	4684	266	4.7	3.4	—	—	1400	2813	—	1162	181	83	.48
105	1	22	4575	207	20.8	—	398	231	209	899	—	1640	239	164	.28
106	1	14	3853	218	17.1	4.6	489	90	154	1935	—	2647	207	138	1.96
6	5	9	3787	—[3]	33.5	3.1	28	—	114	1914[4]	—	1672	222	110	.61
107	1	14	3252	159	5.8	—	—	—	—	870	—	—	272	62	.19
Average		17	5964	293	14.0	6.2	265	148	514	1970[4]	3082	832	217	133	1.44

1 Dairy Section of the Animal Industry Group and Department of Farm Economics of the Kentucky Agricultural Experiment Station cooperated in getting data thru Dairy Herd Improvement Associations. 2 Veterinary fees, medicine, salt and mineral. 3 Data not available. 4 Includes some other hay.

low production. High production becomes uneconomical when pushed to a point where the cost of producing the additional milk exceeds its market value. Frequently, this added production is gotten without regard to the ability of the cow to utilize the additional feeds efficiently.[2] This emphasizes the importance of selecting and breeding a herd with the capacity for economical production, and of feeding according to the ability of each cow to produce economically.[2]

The feed cost for these herds represented approximately 60 percent of the gross costs in producing milk. The kinds and amounts of feeds used and the kinds of pastures provided were important factors influencing the feed costs. The more profitable herds were fed limited amounts of concentrates made up largely of farm-grown grains with sufficient protein concentrates to properly balance the feeds grown on the farm. In addition they made the maximum use of good legume hay and reduced the winter feed period to a minimum by providing ample pasture. Bran, cottonseed meal, commercially mixed dairy feeds and brewers' grains were the principal feeds purchased.

Prices of milk and butterfat. The principal dairy product sold

Table 43. Prices of milk and butterfat.

Year	Whole milk		Butterfat farm price
	Lexington[1]	Cooperating farmers[2]	
	Dollars per cwt.	Dollars per cwt.	Cents per lb.
1924	3.12	—[3]	32
1925	2.76	3.17	38
1926	2.82	2.96	40
1927	2.28	2.94	43
1928	2.33	3.13	44
1929	2.31	—[3]	42
1930	2.16	—[3]	32
1931	2.23	—[3]	22
1932	1.66	1.27	16
1933	1.45	1.17	16
1934	1.80[4]	1.97	20
1935	1.88	1.64	25
1936	1.99	1.79	29

1 Average of monthly quotations for whole milk with 4.5 percent butterfat. Crops and Markets, published by U. S. D. A. 2 Average price received for whole milk by farmers cooperating in the study. 3 Data not available. 4 Somewhat high because quotations were given on the basis of Class 1 milk.

2 Kentucky Extension Circular No. 227, Feeding Dairy Cows, pages 4 and 23.

was whole milk. Two of the farmers sold cream for a part of the time. Two others, during 1924-28, sold some farm-made butter which was retailed in Lexington. This possibly accounts for part of the difference between the Lexington price and the price received by the farmers for these years (Table 43). Another factor influencing this difference is the test of the milk. The Lexington price is based on 4.5 percent butterfat in the milk while the cooperating farmer's prices for 1924 thru 1928 were on the basis of the herd production which probably was higher than 4.5 percent butterfat. In comparing the farmer's price with the market price, the cost of hauling to market must be considered. A charge of 20 to 25 cents per 100 pounds was usually made when the milk was hauled to the plant on a contract basis.

Production and requirements for dairy cows. The data from the herd records presented in Table 42, and experimental data showing the results from different rations were used in computing the feed requirements (Table 44). The three feed combinations are for cows producing annually 6000 pounds of 5-percent milk. The 2.5 acres of good pasture per cow should provide 215 to 250

Table 44. Dairy cows. Production requirements per cow, per year, for an annual production of 6000 pounds of 5-percent milk or 300 pounds of butterfat per cow.

	Combination 1	Combination 2	Combination 3
Feeds:			
Corn, bushels	16	10	16
Barley, bushels	—	8	—
Bran, pounds	200	—	—
Cottonseed meal, pounds	100	200	100
Legume hay, pounds	3000	2500	4000
Corn stover, pounds	1000	—	—
Silage, pounds	—	4000	—
Straw, pounds	500	500	500
Pasture, acres	2.5	2.5	2.5
Labor:			
Man labor, hours	135	135	135
Horse work, hours	2	2	2
Miscellaneous:			
Building and equipment expense, dollars[1]	6.00	6.00	6.00
Other items, dollars[2]	1.50	1.50	1.50

1 Interest, taxes, repairs and depreciation on buildings and equipment used for dairy cows. 2 Veterinary fees, medicine, salt and mineral. If a herd bull is not kept these costs should be increased to include service fees.

days of grazing. If pasture is not available, more concentrates and roughage will have to be fed. By using suitable pasture and high-grade legume hay, the production may be maintained on a minimum amount of concentrates.

The first feed combination provides 8 pounds of concentrates per day for about 150 days. The concentrates are about 11.2 parts corn-and-cob meal, 2 parts bran, and 1 part cottonseed meal. The roughage requirements allow 20 pounds per day of legume hay and 6.7 pounds of corn stover daily for the 150 days. During the remainder of the year the cows will be on pasture.

The second combination substitutes barley for part of the corn and all the bran while the cottonseed meal is increased. Silage is substituted for part of the legume hay. This gives a concentrate mixture of 7 parts of corn-and-cob meal, 3.8 parts of barley and 2 parts of cottonseed meal, and provides 8 pounds daily per cow for 150 days. The roughage requirements allow 16.7 pounds of legume and 26.7 pounds of silage per cow per day for 150 days.

Combination 3 provides less grain and more roughage. The concentrate mixture is made up of 11.2 parts corn and 1 part cottonseed meal and provides 8 pounds daily for 150 days. The roughage requirement allows 26.7 pounds of legume hay per day for the feeding period.

If production is less than 6000 pounds, the amount of grain should be adjusted downward accordingly; if larger, allowance of grain should be increased in proportion.

Relation of dairy cows to other enterprises. The average annual man labor used for the 16 dairy herds was 133 hours per cow. The labor demand was rather uniform for the year, the heaviest during December, January, February, March, and April (Figure 19, page 190). A heavy labor requirement during the winter is typical of herds that freshen in the fall or have a uniform monthly production as is desirable for a whole-milk market.

Dairy cows require a relatively large amount of labor as compared with other kinds of livestock, and fit in well on small farms with considerable available labor. The sale of cream or whole milk brings frequent cash income. If cream is sold, the skimmilk may be used by hogs and poultry. Dairy cows are well suited for

farms favorably situated for selling whole milk, on which production of hay and pasture on a large part of the land is necessary for soil conservation. The manure, properly handled, is an important aid in maintenance of fertility. In this land use situation, beef cattle and sheep compete very closely with dairy cattle since to handle dairy cows profitably most of the concentrates used should be grown on the farm.

YOUNG DAIRY STOCK

Dairymen, on the average, were able to raise well-bred heifers from their best cows as cheaply as they could purchase them from cows of unknown production. Young dairy stock, generally, are raised in three separate groups. The first group includes calves that are being fed for sale as veal; the second group calves under six months old that are being kept for dairy production, and the third group young stock over 6 months old that are being kept for dairy production.

Production requirements for veal calves. The requirements for veal calves provides for the sale of calves at about six weeks old, weighing 140 pounds per head (Table 45). Milk for the first four or five days has not been included. The man labor is for feeding and caring for the calf until ready for sale.

Table 45. Veal calves. Production requirements per head. Weight of calf 140 pounds.

Weight of calf at birth	50 pounds	70 pounds	90 pounds
Production requirements:			
Whole milk, pounds[1]	900	700	500
Man labor, hours	7	6	5

1 Experiments of other stations indicate that about 10 pounds of milk are required for each pound of gain.

Feed, man labor, and materials for young dairy stock under six months old. Feeds represented over 80 percent of the gross cost of raising calves for the first six months. The calves kept by the 10 dairymen for herd replacement varied from practically all winter calves to summer calves (Table 46). On farm number 105 winter calves were kept which resulted in the use of smaller amounts of milk, grain and roughage and more pasture. On the other hand,

Table 46. Dairy calves. Feeds, man labor, and other costs per calf to six months of age, kept for herd replacement, 1931 to 1936[1].

Farm number	Number of years covered	Number of calves	Whole milk	Skim milk	Concentrates						Roughage		Pasture	Man labor	Miscellaneous costs[2]
					Corn	Barley	Bran	Cotton seed meal	Calf meal	Other mill feed	Legume hay	Other roughage			
		head	lbs.	lbs	bus.	bus.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	days	hrs.	dollars
101	1	10.3	522	29	.3	—	—	—	—	218	—	—	38	15	—
105	1	5.9	214	—	.4	—	4	6	5	—	65	—	119	4	.06
98	3	5.8	408	212	1.4	.7	16	23	—	12	193[3]	104	—	10	.02
100	2	5.7	420	—	.5	—	20	12	8	5	60	26	52	5	—
99	1	4.4	448	—	—	—	—	—	189	—	12	—	—	12	—
83	2	4.2	695	71	.7	.2	28	7	—	28	—	—	24	20	.02
102	1	4.2	663	—	.8	—	—	—	37	12	48	—	8	15	—
53	3	3.9	244	1052	.4	2.3	38	2	—	—	45	24[4]	32	17	.02
52	2	3.4	81	1304	.7	—	—	—	—	9	7	—	34	10	.04
103	1	1.6	773	55	2.9	—	36	19	—	14	—	—	—	26	—
Average		4.8	410	316	.7	.5	15	8	14	35	65[3]	30[4]	31	12	.02

1 Dairy Section of the Animal Industry Group and Department of Farm Economics of the Kentucky Agricultural Experiment Station cooperated in getting data thru the Dairy Herd Improvement Associations. 2 Veterinary fees, salt and medicine. 3 Other hay. 4 Silage reduced to a dry roughage basis; 3 pounds of silage equivalent to 1 pound of dry roughage.

farms number 98, 99, and 103 saved summer and fall calves for replacement, which made hay and grain feeding necessary. The better dairymen kept their feed costs low by hand feeding their calves instead of using nurse cows, and by substituting skim-milk for a large part of the whole milk. Bran, cottonseed meal and calf meal were the principal purchased feeds.

Production requirements for dairy calves under six months old, kept for replacing the dairy herd. Feed, labor and other requirements for dairy calves to six months of age were estimated from the data presented in Table 46 together with experimental data showing results where different rations were fed. Requirements for four different feed combinations are suggested (Table 47). Two of the combinations allow good pasture for the calves when four to six months old, and provide for continuation of the grain feeding while the calves are on pasture. The other two combinations have hay instead of pasture, which provides for the calves that will not have an opportunity to graze before they are six months old. It should be noted that these feed combinations provide for the first six

Table 47. Dairy calves. Production requirements per head for calves to six months old.[1]

	Amounts per head semi-annually			
	Combination 1	Combination 2	Combination 3	Combination 4
Feed:				
Corn, bushels	1	.75	1	.75
Barley, bushels	—	.75	—	.75
Bran, pounds	30	—	30	—
Whole milk, pounds	500	500	50	50
Skim-milk, pounds	—	—	1000	1000
Legume hay, pounds	—	150	—	150
Straw, pounds	100	100	100	100
Pasture, acres	.25	—	.25	—
Labor:				
Man labor, hours	10	12	10	12
Miscellaneous:				
Building and equipment expense, dollars	.60	.60	.60	.60
Other items, dollars[2]	.05	.05	.05	.05

1 In calculating a budget using these requirements the average number of calves for six months should be determined; that is, allow for calves born and calves six months old transferred to the young dairy stock group. 2 Medicine and salt.

months feed period for dairy calves that are being kept for replacement of the dairy herd. It is further assumed that these calves will be allowed the colostrum milk for the first four or five days after birth. This milk is not shown in the requirements.

Feed combination 1 provides a milk feeding period in addition to the five days on colostrum milk. This allows about eight pounds of milk per day until the calf is two weeks old. The remaining 428 pounds provides feed for the calf until it is on grain and pasture. This makes possible a tapering off on milk in order to shift to other feeds. The grain mixture is made up of 5.6 parts of crushed or shelled corn and three parts of bran. The pasture with the grain mixture should carry the calf about 90 days. Feed combination 2 differs from the above suggestions in that barley is substituted for the bran and part of the corn, and legume hay is substituted for the pasture. Combinations 3 and 4 suggest the substitution of skim-milk for most of the whole milk, and provides for a longer milk-feed period. On farms with a surplus of skim-milk, in addition to the above requirements and the amount that can be utilized by poultry and hogs, the skim-milk feed period may be continued until the calves are six months old or even older. In this case, more skim-milk will have to be added to the requirements.

Feed, man labor, horse work and materials for young dairy stock over six months old. On the 13 farms dairy stock from six months old to freshening age (about 27 months) was cared for in a group separate from the calves and milking herd. The feeds and labor used are an average per head for a 12-month period (Table 48). Cost of feeds was about 80 percent of the gross cost of raising the young dairy stock. Farm-grown grain and roughage made up the greater part of the feeds used while some bran, cottonseed meal and other mill feeds were purchased. The better dairymen, however, kept the cost low by feeding a grain mixture composed chiefly of farm-grown grains and providing abundant pasture for the young stock past the milk-feeding period.

Production requirements for young dairy stock over six months old. Feed requirements as presented approximate the average amounts used per head annually by a group of young dairy stock ranging from six months old to freshening age (Table 49). In the

Table 48. Young dairy stock over six months of age. Feeds, man labor and other costs per head, per year, 1931 to 1936[1].

Farm number	Number of years covered	Number of young stock	Concentrates					Roughage					Pasture	Man labor	Miscellaneous costs[2]
			Corn	Barley	Bran	Cotton seed meal	Other mill feed	Legume hay	Other hay	Silage	Stover	Other roughage			
			bus.	bus.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	days	hrs.	dollars
101	1	20.6	.1	—	—	—	349	829	—	523	—	291	250	8	.25
98	3	20.3	3.5	1.0	25	53	26	214	436	496	1028	10	173	11	.08
83	2	13.8	1.4	2.7	29	10	218	970	—	839	—	—	245	8	.23
99	1	9.3	5.9	—	—	—	—	990	—	893	—	150	256	9	.33
100	2	8.9	.1	—	1	1	1	—	290	—	1053	694	234	6	.16
53	3	8.8	15.5	3.5	31	15	—	287	—	1549	302	—	253	9	.28
82	2	8.0	—	5.1	62	—	93	2102	—	462	—	—	191	7	.18
104	1	7.2	6.7	—	—	—	—	1229	—	—	—	139	246	18	.19
102	1	6.1	1.2	—	—	34	—	234	—	349	—	—	290	9	.20
106	1	6.0	4.8	—	47	23	—	1309	—	—	—	—	219	11	.28
52	2	5.3	.8	—	—	—	—	168	118	32	—	—	349	5	.12
105	1	5.0	—	—	—	—	—	180	—	—	1440	—	295	5	.08
103	1	4.6	5.1	—	—	—	116	630	—	—	—	—	222	11	.22
Average[3]		10.4	2.1	1.4	20	19	77	601	151	565	443	98	228	9	.18

1 Dairy Section of the Animal Industry Group and Department of Farm Economics of the Kentucky Agricultural Experiment Station cooperated in getting data thru the Dairy Herd Improvement Associations. 2 Salt and medicine. 3 Because of differences in practices this average may not be typical of any herd or group of herds.

feed combinations it is assumed that 240 days of good pasture are available. Where pasture is short or of poor quality, more grain and roughage should be used to offset it.

Table 49. Young dairy stock over six months old. Production requirements[1] per head per year.

	Combination 1	Combination 2	Combination 3
Feeds:			
Corn bushels	5	3	5
Barley, bushels	—	1	—
Bran, pounds	—	50	—
Legume hay, pounds	1000	500	500
Corn stover, pounds	—	1000	—
Silage, pounds	—	—	1500
Straw, pounds	250	250	250
Pasture, acres	1.25	1.25	1.25
Labor:			
Man labor, hours	10	10	10
Horse work, hours	2	2	2
Miscellaneous:			
Building and equipment expense, dollars	.75	.75	.75
Other items, dollars[2]	.25	.25	.25

1 In calculatng a budget it will be necessary to multiply these requirements by the average number of head of young dairy stock on hand during the year for which the budget is being calculated, i.e., allow for calves becoming six months old and heifers freshening during the year. 2 Veterinary fees, medicine and salt.

The first feed combination provides 2.8 pounds of corn-and-cob meal and 8 pounds of legume hay daily for the 125-day winter feed period. In the second, barley and bran are substituted for part of the corn, and stover takes the place of one-half of the legume hay. Combination 3 differs from the first combination in the substitution of silage for one-half of the legume hay.

Relation of young dairy stock to other enterprises. The man-labor requirement for dairy calves averaged twelve hours per head for the first six months (Table 46). This labor demand is quite uniform during the feeding period of the calves. The small total amount of labor, which occurs in the morning and evening, is not a serious factor in competition with other livestock and crops.

The annual labor requirements averaged nine hours per head

for young dairy stock over six months old (Table 48). The peak of labor occurs during December, January, February and March. As in the case of calves, the competition for man labor of young dairy stock over six months old is not a serious factor since only a few head are kept. Thus the total labor demand per farm is not large and comes at a time of year when farm labor is not fully employed.

DAIRY HERD BULL

In commercial dairy sections practically all dairy farmers keep herd bulls. The feed for these bulls varies from a maximum use of roughage and pasture to the feeding of grain and concentrates without pasture. An enterprise cost study of dairy herd bulls for the past several years in the Central Bluegrass Area indicates that the herd sire may be more economically fed by having abundant pasture for him during the pasture season. While the feed cost for a bull may be low if he is allowed to run on pasture with the herd, the heifers are bred too young, the breeding dates are not known and personal danger is increased, objections which more than offset the expense of maintaining a herd sire in a bull lot. The bull lot may be of sufficient size to provide abundant pasture in season and thereby make possible the maintenance of the herd bull in the most economical way.

Feed, man labor, and other costs for herd bulls. Feed represented about one-half the cost of maintaining a herd sire. Corn was the principal concentrate used (Table 50). Legume hay made up the bulk of roughages fed. On farm number 2 the herd bull was fed concentrates and roughages all year. Farm number 105 provided pasture all year which was supplemented with stover during the winter.

Production requirements for dairy herd bulls. The two feed combinations provide for a choice of pasture, grain and roughage or grain and roughage without pasture (Table 51). The first combination suggests the use of good pasture for 240 days followed with 6 pounds of corn and cob meal, 12 pounds legume hay and 8 pounds corn stover, daily, for 125 days. The second combination

Table 50. Dairy herd bull. Feed, man labor, and other costs per head per year, 1931 to 1936[1].

Farm number	Number of years covered	Number of bulls	Concentrates					Roughage					Pasture	Man labor	Miscellaneous costs[2]
			Corn	Barley	Bran	Cotton seed meal	Other mill feed	Legume hay	Other hay	Silage	Stover	Other roughage			
			bus.	bus.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	days	hrs.	dollars
102	1	2	11.1	—	—	—	—	2055	—	1810	—	500	244	28	—
98	1	2	5.1	6.0	—	71	—	286	6200	—	—	—	214	30	—
83	2	1.9	1.5	—	—	—	—	1053	—	—	—	916	249	22	.06
53	3	1.1	.8	1.0	—	—	—	1377	—	—	—	1730	207	31	.29
2	2	1	7.8	—	330	251	154	3682	—	2250	188	—	—	80	1.12
100	2	1	.6	—	14	14	14	1390	—	—	1232	—	275	14	.25
52	2	1	—	—	—	—	—	512	—	—	—	—	336	14	.25
82	2	1	—	8.5	48	266	118	1152	—	—	1298	—	214	44	.06
105	1	1	—	—	—	—	—	—	—	—	1000	—	366	18	.25
99	1	1	8.9	—	—	—	—	1650	—	2440	—	—	244	26	—
101	1	1	2.8	—	—	—	310	2000	—	3060	—	—	214	51	—
103	1	1	18.5	—	—	—	—	2130	—	—	—	—	229	40	—
106	1	1	14.4	—	—	—	—	1065	—	—	—	—	244	28	—
104	1	1	14.9	—	—	—	—	1820	—	—	—	—	214	40	—
6	1	1	5.0	—	—	—	—	300	—	—	2250	—	120	20	.26
Average		1.2	4.7	1.2	30	46	34	1405	473	745	332	170	223	32	.19

1 Dairy Section of the Animal Industry Group and Department of Farm Economics of the Kentucky Agricultural Experiment Station cooperated in getting data thru the Dairy Herd Improvement Association. 2 Salt and medicine.

provides about 3 pounds of corn and cob meal, 1.3 pounds barley, 10 pounds legume hay and 8 pounds of stover, daily.

Table 51. Dairy herd bull. Production requirements per head, per year.

	Combination 1	Combination 2
Feed:		
Corn, bushels	10	15
Barley, bushels	—	10
Legume hay, pounds	1500	3650
Stover, pounds	1000	3000
Straw, pounds	200	500
Pasture, acres	2.5	—
Labor:		
Man labor, hours	30	75
Miscellaneous:		
Depreciation, dollars[1]	12.50	12.50
Shelter, dollars	2.50	2.50
Other items, dollars[2]	.35	.35

1 Depreciation varies with purchase and sale price and years of service. 2 Veterinary fees, medicine, and salt.

HOGS

In the agriculture of the Inner Bluegrass region hogs furnish a considerable part of the cash income on many farms besides supplying all or a large part of the pork consumed by farm families.

Feed, man labor, and other costs for hogs. The number of sows per farm varied from 1.2 to 22, for the 43 farms. The average annual pork production ranged from 2400 to 44650 pounds per farm (Table 53).

Feed represented over 85 percent of the gross cost of producing pork for these 43 farmers. The more efficient farmers obtained one hundred pounds of gain from six bushels or less of corn or its equivalent. Low corn requirement was closely associated with rapid gain. Feeding for rapid gain made it possible for the more successful hog producers to get each hundred weight of gain in one-third less time than the less successful farmers. Unthrifty hogs and light feeding which failed to produce rapid gains resulted in large feed requirements.

Price of hogs. The average annual price for top hogs at Cincinnati from 1925 to 1936, Kentucky farm prices from 1921 to 1936

and prices received by the 43 farmers included in this study during 1921 to 1928 and 1932 to 1936 are shown in Table 52.

Table 52. Hogs. Price per 100 pounds, 1921-36.

	Cincinnati (tops)[1]	Kentucky farm price[2]	Cooperating farms[3]
	dollars	dollars	dollars
1921	—[4]	8.03	8.91
1922	—[4]	8.62	9.49
1923	—[4]	7.11	7.11
1924	—[4]	7.47	8.34
1925	11.60	11.30	11.97
1926	12.08	12.38	13.04
1927	9.84	10.09	10.18
1928	10.17	8.84	9.31
1929	10.85	9.68	—[4]
1930	10.21	9.17	—[4]
1931	7.04	6.51	—[4]
1932	4.25	3.88	3.63
1933	4.34	3.73	3.70
1934	5.25	4.38	4.85
1935	9.89	8.78	9.92
1936	10.39	9.50	10.05

1 Average of monthly prices as reported in "Notes on Kentucky Agricultural Situation" prepared by Department of Markets and Rural Finance. 2 Average of monthly prices for Kentucky as reported in "Crops and Markets" published by U. S. D. A. 3 Average price received by farmers included in this study. 4 Data not available.

Production requirements for fat hogs. The data given in Table 52 together with experimental data showing results when different rations were fed, were used in working out the feed, labor and other requirements for hogs. The feed combinations provide for good pasture in season. The three combinations make possible the choice of a mixture that may be suited to the feeds available on the farm. The first combination provides a corn ration supplemented with bran and shorts and tankage (Table 54). Barley is substituted for part of the corn and all the bran and shorts in the second combination, while skim-milk is substituted for tankage. When skim-milk is fed, slightly less concentrate is required than when tankage is fed. Feed combination 3 presents a corn and tankage feed mixture.

Production requirements for raising feeder pigs. In this area a considerable number of farmers raise feeder pigs to weights of 75 to 100 pounds and sell them to other farmers who fatten them for

Table 53. Hogs. Feed, man labor, and other costs in producing 100 pounds of pork, 1921 to 1928 and 1932 to 1936. Farms arranged in the order of corn equivalent, exclusive of tankage, per 100 pounds of pork produced, beginning with the lowest.

Farm number	Number of years covered	Pork produced annually	Corn equivalent	Corn	Barley	Wheat	Tankage	Other mill feed	Skim-milk	Distillery slop	Pasture	Man labor	Miscellaneous costs[1]
		cwt.	bus.	bus.	bus.	bus.	lbs.	lbs.	lbs.	lbs.	days	hrs.	dollars
4	1	24.0	3.9	2.4	1.8	—	—	—	—	—	19	2.8	—
30	1	38.0	3.9	3.8	—	—	—	—	81	—	73	2.9	.03
53	5	66.8	4.8	3.0	1.2	.2	—	6	275	52	60	3.0	.01
19	2	112.1	5.0	4.1	1.0	—	—	—	55	—	9	2.0	—
24a	5	42.3	5.1	4.6	—	.2	—	3	121	51	64	2.6	—
31	5	59.9	5.4	3.0	.8	1.5	—	25	55	—	61	2.4	.01
32	1	87.5	5.5	5.1	—	.3	—	—	—	—	96	1.9	.01
16a	1	334.0	5.6	5.4	—	.2	1	—	2	—	53	.8	—
20a	3	74.5	5.6	3.8	—	1.8	—	—	—	—	66	1.5	.01
44	5	55.7	5.7	5.0	—	—	6	—	—	369	75	2.9	—
16	3	136.0	5.9	5.8	—	—	—	—	36	4	14	1.9	.01
9	11	297.1	5.9	5.3	—	.4	1	9	2	—	47	1.2	.08
26a	5	177.9	5.9	3.4	1.4	.9	—	6	178	—	85	1.4	.05
36	2	61.6	6.0	5.0	—	1.0	—	7	2	—	119	1.6	.02
15a	1	203.8	6.0	5.4	.6	—	—	2	—	—	32	1.1	—
52	5	123.9	6.0	5.5	—	—	—	1	262	—	47	2.1	—
9a	5	44.2	6.2	3.7	2.2	—	—	2	158	227	69	4.5	.02
18	2	58.8	6.2	5.1	—	.8	—	—	140	—	36	3.4	—
25a	2	112.0	6.2	4.8	1.1	.4	—	—	—	74	49	3.0	.10
43	2	82.2	6.3	4.0	—	2.6	—	—	—	—	95	1.3	.01

17a	1	156.4	6.4	6.4	—	—	—	—	—	—	106	1.8	.61
21	2	446.5	6.5	4.7	2.0	.2	1	—	—	—	45	2.1	.26
24	7	41.1	6.6	4.1	2.2	.3	2	3	151	14	72	4.6	.02
17	3	88.2	6.6	6.3	—	.3	3	4	—	—	12	1.6	.08
34	1	41.1	6.6	6.2	—	—	—	9	132	—	153	3.1	.12
1	6	180.4	6.7	6.5	.1	—	—	4	—	4	8	.1	.13
10a	5	113.3	6.7	5.1	1.2	—	—	16	5	200	66	1.4	.02
23a	5	33.5	6.8	1.4	5.3	—	—	—	552	—	64	3.4	.01
10	1	254.0	6.9	6.8	—	.1	—	—	—	—	12	1.4	—
7	10	144.4	7.0	5.0	.6	1.2	6	20	22	—	19	1.5	.07
23	1	120.9	7.1	6.0	—	.9	17	—	95	—	10	2.0	—
11a	4	96.8	7.3	5.7	—	1.2	—	—	26	302	66	2.1	—
5	2	164.4	7.4	7.3	—	—	—	—	19	—	8	1.3	.05
14a	1	119.4	7.9	5.8	1.9	.2	—	27	—	—	56	2.2	.01
6	11	123.9	8.3	7.8	—	.2	1	4	120	20	15	1.8	.10
25	1	228.3	8.9	8.5	.5	—	—	—	—	—	7	1.2	.08
8	1	193.6	9.0	8.8	.2	—	—	—	—	—	14	1.4	.05
22	4	129.7	9.5	7.1	2.3	—	9	24	58	—	43	2.7	.14
20	1	61.9	9.5	8.0	1.9	—	—	—	—	—	14	3.1	—
33	5	89.3	9.6	8.4	.6	.7	4	—	3	37	52	1.7	.02
12	1	85.8	10.1	10.1	—	—	1	—	—	—	11	2.1	—
13	3	107.5	10.5	9.8	—	—	5	46	—	—	57	2.2	—
3	2	95.2	10.6	9.7	—	.9	—	—	—	—	6	2.1	.32
Average		122.9	6.8	5.7	.6	.4	2	7	53	27	43	1.8	.06

1 Veterinary fees, medicine, salt, mineral, oil and rings.

market. The three feed combinations for raising feeder pigs provide opportunities to utilize the feeds on the farm. They allow

Table 54. Fat Hogs. Production requirements per 100 pounds live-weight gain, including requirements for keeping sows.

	Combination 1	Combination 2	Combination 3
Feed:			
Corn, bushels	6	3	7
Barley, bushels	—	4.5	—
Bran and shorts, pounds	80	—	—
Tankage, pounds	15	—	20
Skim-milk, pounds	—	300	—
Pasture, acres	.1	.1	.1
Labor:			
Man labor, hours	2	2	2
Miscellaneous:			
Shelter and equipment expense, dollars	.10	.10	.10
Other items, dollars[1]	.05	.05	.05

1 Veterinary fees, medicine, salt, oil and rings. Expense of vaccination against cholera is not included.

shifting from skim-milk to tankage and substituting barley and shorts for corn.

Production requirements for fattening 75- to 100-pound feeder pigs. The feed combinations for fattening feeder shotes provide a

Table 55. Feeder pigs. Production requirements for 100 pounds of live-weight gain, including keep of sows.

	Combination 1	Combination 2	Combination 3
Feed:			
Corn, bushels	5	3	6.5
Barley, bushels	—	4	—
Shorts, pounds	100	—	—
Tankage, pounds	—	5	15
Skim-milk, pounds	250	150	—
Pasture, acres	.2	.2	.2
Labor:			
Man labor, hours	3	3	3
Miscellaneous:			
Shelter and equipment expense, dollars	.10	.10	.10
Other items, dollars[1]	.05	.05	.05

1 Veterinary fees, medicine, salt, oil and rings. Expense of vaccination against cholera is not included.

choice of feed mixtures in order to use the feeds found on different farms (Table 56).

Table 56. Fattening feeder pigs. Production requirements for 100 pounds liveweight gain.

	Combination 1	Combination 2	Combination 3
Feed:			
Corn, bushels	6.5	4	7.5
Barley, bushels	—	4.5	—
Shorts, pounds	75	—	—
Tankage, pounds	—	5	15
Skim-milk, pounds	200	100	—
Pasture, acres	.1	.1	.1
Labor:			
Man labor, hours	1	1	1
Miscellaneous:			
Shelter and equipment expense, dollars	.10	.10	.10
Other items, dollars[1]	.05	.05	.05

1 Veterinary fees, medicine, salt, oil and rings. Expense of vaccination against cholera is not included.

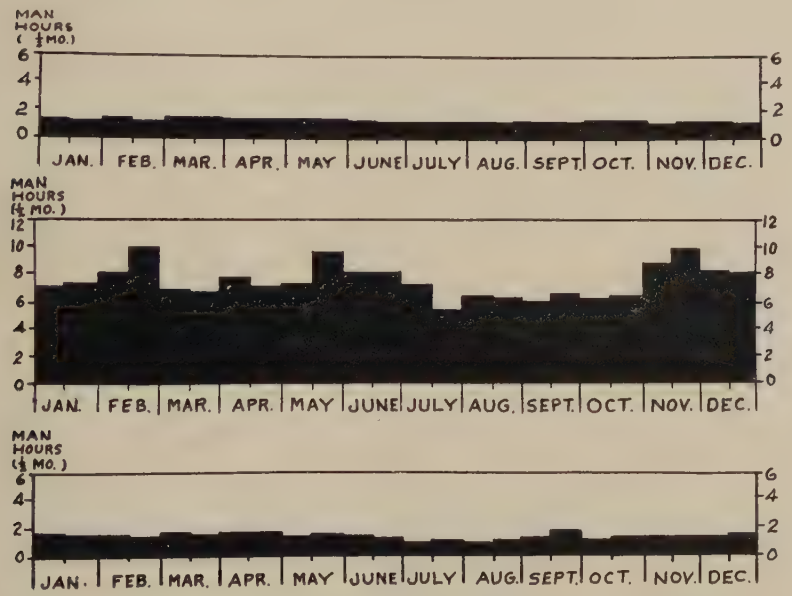


FIGURE 20 (Upper). Seasonal distribution of man labor for a sow and 10 pigs.
FIGURE 21 (Middle). Chickens. Seasonal distribution of man labor for 100 mature birds.
FIGURE 22 (Lower). Workstock. Seasonal distribution of man labor per head.

Relation of hogs to other enterprises. The annual man labor requirements averaged about 35 hours per sow. Seasonal distribution of man labor was relatively uniform for the year (Figure 20, page 215). The largest labor requirement was during the spring farrowing, and the smallest, during the pasture period from June to September. The competition of hogs with other farm enterprises, for labor, was not important, since the total amount required was comparatively small.

Hog production in the Central Bluegrass region is to a large extent a by-product of other enterprises. Where dairy cattle are kept for the production of butterfat to be sold as cream, the hogs fit in very well to utilize the skim-milk. In beef production where feeder cattle are grain fed, hogs are well suited to reclaim the undigested grain. They are of further importance in supplying a large part of the farm meat. On farms where a surplus of grain or skim-milk is produced or where beef cattle are grain fed, it will usually be advisable to produce a surplus of pork for sale.

CHICKENS

In Central Kentucky chickens are kept primarily to supply meat and eggs for the farm family. Since raising chickens is seldom a commercial enterprise, flocks on most farms are small, ranging from 50 to 100 birds. The number has not changed much since 1900. In that year there were 45 birds for each 100 acres of farm land. The number increased to 69 per 100 acres, in 1920, and decreased to 55 per 100 acres, 1930. Chickens are largely scavengers in that a considerable amount of their feed is picked up around the farmstead and adjoining fields. The feed reported by the farmers in this study was only that used in addition to the otherwise waste feeds picked up about the farm. Chickens require primarily grain and protein concentrates or skim-milk, with some pasturage. In the chicken enterprise farm-grown grain, fresh water, and a good range free from parasites are essential for economical production.

Prices. The average annual Kentucky prices of chickens and eggs, from 1921 to 1936, are presented in Table 57.

Production requirements for chickens. Feed and other requirements are suggested for chickens producing annually 10 dozen eggs,

Table 57. Chickens. Kentucky farm prices for chickens and eggs, 1921 to 1936[1].

Year	Chickens per pound	Eggs per dozen
	cents	cents
1921	19.5	30.3
1922	18.0	25.6
1923	17.8	27.3
1924	18.2	27.9
1925	19.1	30.1
1926	21.3	28.8
1927	19.6	26.1
1928	20.7	28.5
1929	22.0	30.7
1930	17.5	24.3
1931	14.9	17.1
1932	10.6	14.0
1933	8.5	13.3
1934	10.6	16.6
1935	14.1	22.0
1936	14.7	21.6

1 Average monthly prices as reported in "Crops and Markets" published by U. S. D. A.

four pounds of fryers and four pounds of cull hen per mature bird (Table 58). The three combinations include the necessary feeds for small flocks kept on free range under ordinary farm conditions.

Table 58. Chickens. Requirements per mature bird, per year. Production, 10 dozen eggs, 4 pounds of fryers and 4 pounds of hens.

	Combination 1	Combination 2	Combination 3
Feed:			
Corn, grain, bushels	1.5	1.5	1.2
Corn, ground, pounds	10.0	8	20
Mixed wheat feed, pounds	3.5	17	20
Meat scrap, pounds	—	2	10
Oyster shell or limestone chips, pounds	4	4	4
Skim-milk, pounds	160	100	—
Labor:			
Man labor, hours	3	3	3
Miscellaneous:			
Building and equipment, dollars	.20	.20	.20
Salt, dollars[1]	.01	.01	.01

1 No expense for artificial hatching and brooding. Where contract hatching is done this expense should be added.

In the first combination, one and one-half bushels of corn and 160 pounds of skim-milk are for each mature bird. The remainder of the feed is for the young birds that will be raised for replacement

and to be sold or used by the farm family as fryers. Combination 2 is a home-mixed mash in which some meat scrap is substituted for part of the grain and part of the skim-milk in combination 1. In the third combination protein supplements have been substituted for milk.

Relation of chickens to other enterprises. The man labor required for chickens handled under ordinary farm conditions is comparatively small, the heaviest demand being at the hatching and brooding season. (Figure 21, page 215.) Chickens are well suited to farms producing grains where plenty of feed is available for them, and especially well suited to farms producing a surplus of skim-milk.

WORKSTOCK

The number of horses and mules in Central Kentucky has decreased since 1910. About two-thirds of these animals are horses and one-third mules. The proportion of horses for this area is somewhat larger than necessary for farm power, since some of them are Thoroughbreds, Standard Breds and Saddle Horses not used for farm work. The number of mules on farms in this region is larger than needed for farm work because some mules are raised for sale to the southern states. Workstock, however, make up the greater proportion of horses and mules on the farms of this area.

Feed, man labor and materials used for workstock. Only animals of working age were included in this study. The work per horse ranged from 655 hours to 1171 hours per year per head, and averaged 885 hours, for the 21 farms (Table 59).

The wide variation in work done per horse (shown in Table 59) suggests the need for careful planning of farm work. Where the farm work is poorly planned it comes in peaks which require a relatively large number of horses for short periods, but for the remainder of the year the work animals have little or no work.

The grain fed per horse averaged 40 bushels of corn and varied from 29 bushels to 64 bushels per horse, per year. Hay varied from 667 pounds to 4733 pounds, averaging 2906 pounds per horse, annually. Corn stover was used to supplement hay on most farms. On all farms, horses were pastured, from 97 to 260 days per horse per year, with an average of 174 days.

Production requirements for workstock. The production re-

Table 59. Workstock. Feed, man labor, horse work and hours worked per horse per year, 1921 to 1928. Arranged in the order of hours worked per horse, beginning with the largest.

Farm number	Number of years covered	Number of head	Work per horse	Corn	Hay	Stover	Straw	Pasture	Man labor	Horse work	Miscellaneous costs[1]
			hours	bus.	lbs.	lbs.	lbs.	days	hours	hours	dollars
18	1	5	1171	31.1	2790	—	1000	240	32.5	12	2.06
25	1	6	1119	54.3	667	750	—	244	31.5	4.7	1.46
14	2	4	1062	64.3	729	58	—	173	59.1	12.6	2.71
21	3	6	1061	35.3	1478	3027	120	206	40.2	23.8	1.23
4	1	3	1042	39.6	3333	350	—	247	42.7	—	2.00
22	4	5	981	51.6[2]	2449	1009	895	160	58.0	11.7	3.01
19	3	5	970	43.1	2216	1808	257	97	40.3	.3	2.87
6	8	5	928	47.2[2]	2482	1922	734	147	46.7	15.3	2.46
13	4	5	902	52.4[2]	1801	2525	109	132	60.6	10.7	3.83
23	1	5	902	41.0[2]	3200	660	400	99	39.5	3.0	—
16	4	3	898	43.3	2880	1725	808	152	48.2	8.7	4.65
5	2	6	868	33.1	2772	1450	167	260	29.2	5.0	1.69
7	6	6	863	29.1[2]	3432	1124	684	208	45.6	5.7	2.56
12	1	6	858	34.9[2]	2204	1907	508	102	34.0	7.8	1.74
1	7	8	835	42.8[2]	4733	311	853	166	37.0	1.8	5.08
20	1	7	823	31.2[2]	3229	1393	286	149	35.0	—	2.40
17	3	5	818	33.1[2]	2584	2025	250	191	46.7	18.6	5.14
9	7	7	792	30.5[2]	3029	509	371	180	27.5	1.0	2.33
2	4	2	726	48.0[2]	2675	1181	—	180	60.1	1.5	5.07
24	1	4	706	28.6[2]	2800	2250	1000	98	48.5	14.0	1.96
8	1	6	655	42.3[2]	2484	2250	—	118	44.5	10.3	.33
Average		5	885	40.0[2]	2906	1259	509	174	42.1	7.6	3.02

1 Veterinary fees, medicine, horse shoeing and salt. 2 Small amounts of barley and mill feed considered as corn, pound for pound, and oats considered two pounds equal to one pound of corn.

quirements presented in Table 60 assume 900 hours of work per horse per year. The 1.5 acres of good pasture provide 175 to 200 days of pasture. Two feed combinations present an opportunity to substitute corn stover for part of the hay. If horses are worked more than indicated or if pasture is not available for the required number of days, more feed will be needed. The man labor required to care for horses averaged 42 hours per horse per year (Table 59). This labor is fairly uniform for the year with a slightly heavier requirement during the winter and spring (Figure 22, page 215).

Table 60. Workstock. Production requirements per head, per year. Assumed production, 900 hours of work.

	Combination 1	Combination 2
Feed:		
Corn, bushels	40	40
Hay, pounds	3500	3000
Stover, pounds	—	1000
Straw, pounds	500	500
Pasture, acres	1.5	1.5
Labor:		
Man labor, hours	40	40
Horse work, hours	7	7
Miscellaneous:		
Depreciation, dollars	10.00	10.00
Shelter, dollars	7.50	7.50
Equipment, dollars	5.00	5.00
Miscellaneous, dollars[1]	3.00	3.00

1 Veterinary fees, medicine, shoeing and salt.

CROP AND LIVESTOCK BALANCE

In any system of farming in the bluegrass region the balance between crops and livestock is an important consideration. Usually, on the farm where Burley tobacco is an important source of income, a relatively long rotation is used to produce a good yield of high-quality tobacco. The long rotation desirable for tobacco encourages a relatively large acreage of pasture. Livestock plays an important part in the economical use of this pasture. In deciding the kind and number of livestock to be kept several factors must be considered: (1) the size of the farm; (2) the type and productiveness of the soil; (3) the topography; (4) the length of rotation necessary to maintain or improve fertility and prevent erosion; (5)

the proportion of feed and pasture required for specific kinds of livestock; (6) market opportunities; (7) the operator's personal likes and dislikes.

Farmers do not think primarily of single crop or livestock enterprises but rather of crop and livestock combinations. Usually the farm enterprises are planned so as to use as nearly as practicable the same labor force and teams thruout the year. Thus the proper fitting together of crops and livestock is necessary in order to provide as uniform a demand for man labor and teams as possible and at the same time to produce the largest continuous net income to the operator. As an aid in determining the proper combination of crop and livestock enterprises a summary of land and labor requirements is presented in Tables 61 and 62. In deciding whether or not the best balance of enterprises that will result in the largest net earnings over a period of years has been attained, it is necessary to know the approximate amounts of land, labor and horse work needed for each enterprise.

Table 61. Land and labor requirements for cash crops.

	Cultivated land	Hay and pasture land	Man labor	Horse work
	acres	acres	hours	hours
1 acre of tobacco	1	—	300	90
1 acre of wheat	1	—	6	11
1 acre of bluegrass seed	—	1	3	2

On most farms of the bluegrass region tobacco is the major cash crop with a livestock enterprise as the second important source of income. When the major sources of income have been decided upon[1] and sufficient products have been provided for the farm family, other crops and livestock should be added that utilize any available land, feed crops, man labor and horse work, in order to furnish a cash income from men, teams, and such unmarketable products as stover, pasture and skim-milk. This assumes that cash income from man labor, horse work and crop land will be larger from the major crop and livestock enterprises than from the other enterprises. However, the total net returns from all sources will be

1 Kentucky Experiment Station Bulletin 312. "The Budget Method of Improving Farm Organization and Management."

larger if minor enterprises are included to furnish additional cash income from the unmarketable feeds and the available labor that otherwise would not be fully utilized.

Table 62. Land and labor requirements for livestock, including requirements for growing feed crops and pasture[1].

	Cultivated land	Hay and pasture land	Man labor	Horse work
	acres	acres	hours	hours
For 5 mature sheep and lambs:				
Corn, 1¼ bushels	.03	—	1.1	1.1
Oats, 3¾ bushels	.11	—	1.0	1.8
Alfalfa hay, 1000 pounds	—	.2	3.6	4.8
Pasture	—	2.5	1.2	—
Care of flock	—	—	25.0	5.0
Total	.14	2.7	31.9	12.7
Production: Lambs 450 pounds Wool 35 pounds				
For one beef cow producing fat calf:				
Corn, 12 bushels	.27	—	10.0	10.3
Clover hay, 2750 pounds	—	.9	9.2	9.2
Corn stover, 1000 pounds	—	—	—	—
Pasture	—	2.5	1.2	—
Care of cow and calf	—	—	15.0	2.0
Total	.27	3.4	35.4	21.5
Production: Calf 500 lbs. Cull cow 100 lbs.				
For one beef cow producing feeder calf:				
Corn, 1 bushel	.02	—	.7	.8
Cottonseed meal, 50 pounds	—	—	—	—
Corn stover, 4000 pounds	—	—	—	—
Pasture	—	2.5	1.2	—
Care of cow	—	—	10.0	2.0
Total	.02	2.5	11.9	2.8
Production: Calf 375 pounds Cull cow 100 pounds				
For one light feeder steer:				
Corn, 15 bushels	.33	—	12.3	12.7
Clover hay, 600 pounds	—	.2	2.0	2.0
Corn stover, 2400 pounds	—	—	—	—
Pasture	—	2.1	1.1	—
Care of feeder	—	—	7.5	—
Total	.33	2.3	22.9	14.7
Production: 300 pounds gain in live weight				

For one dairy cow:				
Corn, 10 bushels	.22	—	8.1	8.4
Barley, 8 bushels	.23	—	1.4	2.5
Cottonseed meal, 200 pounds	—	—	—	—
Alfalfa hay, 2500 pounds	—	.5	9.0	12.0
Silage, 4000 pounds	.2	—	8.8	12.0
Pasture	—	2.5	1.2	—
Care of cow	—	—	135.0	2.0
Total	.65	3.0	163.5	36.9
Production: Milk 6000 pounds				
For one sow and pigs:				
Corn, 140 bushels	3.1	—	114.7	117.8
Tankage, 400 pounds	—	—	—	—
Pasture	—	2.0	1.0	—
Care of hogs	—	—	40.0	—
Total	3.1	2.0	155.7	117.8
Production: 10 pigs, 200 pounds each				
For 100 hens and chicks:				
Corn, 156 bushels	3.5	—	129.3	132.8
Oyster shell, 400 pounds	—	—	—	—
Mixed wheat feed, 2000 pounds	—	—	—	—
Meat scrap, 100 pounds	—	—	—	—
Care of chickens	—	—	300.0	—
Total	3.5	—	429.3	132.8
Production: Eggs 1000 dozen Fryers 400 pounds Hens 400 pounds				
For one horse:				
Corn, 40 bushels	.9	—	33.3	34.2
Timothy hay, 3000 pounds	—	1.2	8.4	8.4
Corn stover, 1000 pounds	—	—	—	—
Pasture	—	1.5	.8	—
Care of horse	—	—	40.0	7.0
Total	.9	2.7	82.5	49.6
Production: Horse work 900 hours				

1 The requirements shown include the land, man labor, and horse work used in providing the following feed combinations:

Sheep	Combination 1, Table 62
Beef cows producing fat calves	Combination 2, Table 38
Beef cows producing feeder calves	Combination 1, Table 39
Light feeder steer	Combination 3, Table 41
Dairy cow	Combination 2, Table 44
Sow and pigs	Combination 3, Table 54
100 hens and chicks	Combination 3, Table 58
Horse	Combination 2, Table 60

Kentucky
Agricultural Experiment Station

University of Kentucky

FACTORS FOR PROFITABLE FARMING ON LIMESTONE HILL LAND OF THE EDEN FORMATION IN KENTUCKY

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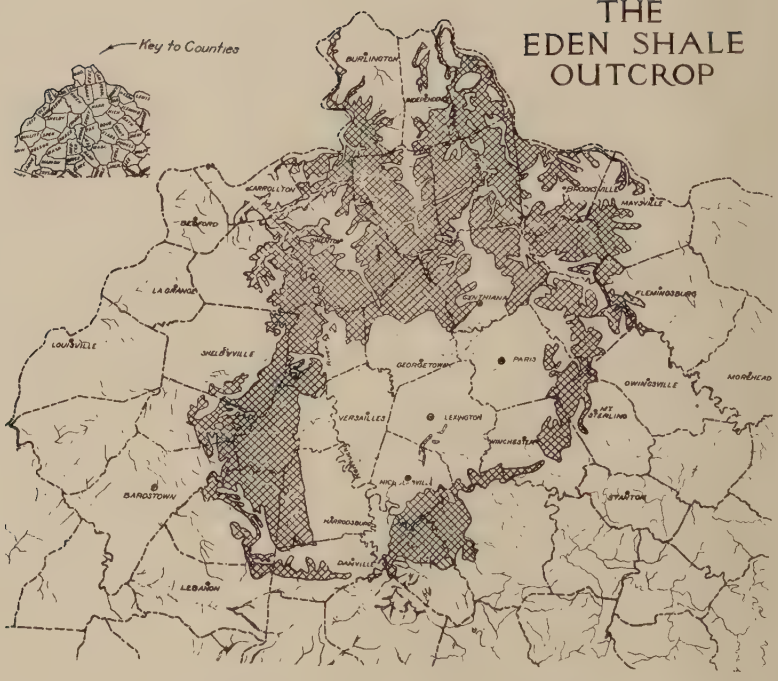

FIGURE 1. The outcrop of the Eden formation.

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FACTORS FOR PROFITABLE FARMING ON LIMESTONE HILL LAND OF THE EDEN FORMATION IN KENTUCKY

JOHN H. BONDURANT[1]

INTRODUCTION

This study is based upon an analysis of 134 farms in the hill section of Anderson, Garrard, Mercer, and Washington Counties, for the year 1935. These counties are in the limestone hill land of the Intermediate Bluegrass Area of Central Kentucky, figure 1. Forty-two of the farms are in Anderson, 3 in Garrard, 64 in Mercer, and 25 in Washington County. The section of the counties in which these farms are located is a part of the Eden Shale belt. This belt consists of a large part of the counties of Anderson, Bracken, Campbell, Clark, Franklin, Gallatin, Garrard, Grant, Harrison, Henry, Madison, Mercer, Montgomery, Nicholas, Owen, Pendleton, Robertson, Scott, Shelby, Spencer and Washington, and a small part of other bluegrass counties. This embraces an area of about 2500 square miles and surrounds the Inner Bluegrass Area of Central Kentucky in a belt of varying width.

The 134 farms were selected as a fair example of the type of farming carried on in the limestone hill land section of the Eden Shale belt. They are representative of all the farms in the area, and are operated by farmers who derive all or a major part of their incomes from the farm. The data upon which the study is based were gathered by interviewing each farm operator, on the farm.

The farms studied are well located with respect to markets. All-weather automobile roads are accessible to practically all of them thus making it possible to transport agricultural products to local and outside markets at any season. Louisville and Cincinnati are the central marketing places for the livestock produced in the re-

1 Acknowledgements: E. F. Daniel, James Downing, E. J. Nesius, W. W. Rose and James D. Toy served as field assistants in gathering the data from the 134 farms. Mr. Daniel, besides the work done in getting the data of the study, also assisted in the supervision of the tabulations and the analysis of the data.

gion. The local markets are Lawrenceburg, Lancaster, Springfield, and Harrodsburg. Most of the tobacco is marketed at Lexington.

The climate is well suited to the production of most of the crops grown in the North Central states. Crop production, however, is limited by the rough topography which necessitates the use of only horse-drawn implements, and by the heavy clay soil, which limits the days suitable for plowing by changing quickly from too wet to too dry. The growing season is approximately six months, with hot summers and an average rainfall sufficient for most of the crops grown. The distribution of rainfall is such that the production of some crops is greatly affected in many seasons, particularly those that grow or mature in July or August. Drouths often occur at this time and seriously affect both crop and pasture growth. The first killing frost may be expected in the latter part of October, and the last in the spring, in the middle or latter part of April.

Soil and topography are fairly uniform thruout the limestone hill land region and appear to have a marked influence on the type of agriculture. The surface relief is characterized by narrow ridges and V-shaped valleys with very little bottom land except along the larger streams. The land ranges from a gentle slope on the ridge tops to a steep slope on the hillsides. Nearly all the soils on the farms studied are derived from calcareous shales and thin limestones. These soils are brown to brownish yellow silty clay loams and clay loams and are classified in the Eden series. They are neutral or alkaline and frequently contain calcium or magnesium carbonate. Numerous fragments of limestone are present on the surface and scattered thru the soil. These range from one to four inches in thickness and from a few inches to twenty or more inches in diameter.

On the ridge tops and less steep slopes where erosion has been less the soil is deeper and the stones are not so numerous. Here the soil is two to five feet deep. On the steeper slopes with greater erosion, the soil is from a few inches to approximately two feet deep and stones are very numerous. This land is severely eroded in many places and is not suitable for the production of intertilled crops. Bluegrass grows well on this land and furnishes good pasture except in dry seasons. Almost all the original surface soil has been

removed from some parts of this area. Such areas are generally found to be partially covered by cedars, scrubby trees and brush. In the soil survey of Mercer County (United States Department of Agriculture, Series 1930, No. 23) these soils are mapped as Eden silty clay loams and Eden stony clay loams, depending upon the prevalence of the stones. These Eden soils are known locally as limestone hill land.

In a few places on the ridge tops the soil is derived from fine-grained thin sandstones and shales instead of limestones and shales. This soil is a light brown to brownish yellow silt loam and is moderately to strongly acid. It is similar to the soil classified in the Culleoka series in the soil survey report of Garrard County (United States Department of Agriculture, Advance Sheets—Field Operations of the Bureau of Soils, 1921) [1].

The soils in this area, except those derived from sandstone, are fairly well supplied with phosphorus, and the available potassium is sufficient for most crops, but the nitrogen content varies with the amount of erosion. The productivity of much of the land has been greatly lessened by too frequent growing of intertilled crops and the attendant erosion.

On the 134 farms of this study, 70 percent or more of the land of each farm was Eden silty clay loam and Eden Stony clay loam or similar soil. On 120 farms, 85 to 100 percent of the land was of this character. On the remaining 14 farms the proportion was 75 to 85 percent[2].

The 120 farms were divided into two groups according to the percentage of bottom land. In one group were 94 farms which had less than eight percent of bottom land; in the other, 26 had eight percent or more. Altho the limestone land in both groups ranged from 85.1 to 100 percent, it appeared that the farm organization was different, in some respects, on the farms with eight percent or more of bottom land. For example, an average of 50 percent more brood sows per farm were kept on these farms and the yield of corn was approximately 20 percent greater than on the

1 This soil was classified as Muskingum silt loam in the Soil Survey of Mercer County.

2 An average of eighty percent of the land in the 120 farms was classified by the farmers interviewed as steep, 14 percent as rolling and 6 percent level or bottom land.

farms with less than eight percent of bottom land. For this reason the factors for successful farm organization and management for the two groups, as well as for the remaining 14 of the 134 farms, are discussed separately.

LAND UTILIZATION

The area operated on the 94 farms averaged 93 acres, and ranged from 39 to 292 acres; 88 farms had between 50 and 150 acres. Approximately 29 percent of the land was in crops and 65 percent in pasture. The remaining 6 percent was idle land, woods not pastured, land used for buildings, roads, lots, and waste land. The 65 percent of pasture land consisted of 12 percent rotation pasture, 37 percent tillable permanent pasture (usually a part of a rotation extending from 10 to 20 years between plowings for cultivated crops), 15 percent brush pasture, and one percent pastured woods. The land utilized for harvested crops averaged 26.8 acres per farm. Corn, tobacco, alfalfa, and garden products were produced on more than half of the 94 farms, table 1. Also, more than half of the acreage of crops harvested was corn or alfalfa. The tillable land per farm averaged 75 acres; 48 acres, or nearly two-thirds, of this was pasture, mostly bluegrass; 11 acres were in cultivated crops, and 4 were in small grain.

Table 1. Crops harvested on 94 limestone hill land farms. 1935.

Crop	Number of farms	Acres per farm	Percent of crop area	Yield per acre
Corn	93	8.5	31.2	26.4 bus.
Tobacco	90	1.5	5.3	819.0 lbs.
Sorghum	45	1.1	2.0	-*
Wheat	46	7.2	13.1	7.5 bus.
Hay (oats or wheat)	16	4.4	2.8	.7 tons
Alfalfa hay	69	11.4	31.3	1.7 tons
Mixed hay	30	6.6	7.8	.9 tons
Lespedeza hay	17	5.3	3.5	1.2 tons
Garden†	94	.7	2.8	-
Miscellaneous	3	1.7	.2	-
Total	94	26.8	100.0	

* Part of the sorghum produced was used for feed and part for syrup.
† Home orchards on a few farms are included with the garden acreage.

Wheat, the principal small grain, was harvested for grain on 46 farms and covered approximately 13 percent of the crop area.

Part of the wheat acreage seeded was not harvested but used for pasture only. Wheat and oats harvested as hay were produced on 16 farms or approximately three percent of the crop area of all farms. These small grains served three purposes; as a cover crop, as a nurse crop for the seeding of grasses and legumes, and as a hay crop. Alfalfa was the outstanding hay crop in yield as well as acreage. All other hay, including small grain cut for hay, amounted to 14.1 percent of the crops harvested.

LIVESTOCK

Dairy cows, sheep, poultry, and workstock were the principal livestock kept on the 94 farms. Dairy cows were found on all farms except one, and the number ranged from 1 to 14. On 91 farms there were two cows or more, and on 90 farms dairy products were sold, principally whole milk to local cheese plants. On more than three-fourths of the farms there were 3 to 94 ewes, and on 56 there were 20 to 60. Hens were kept on all the farms, ranging in number from 10 to 175 and averaging 68. Turkeys were found on 59 farms and the breeding flock ranged from 2 to 18. Eighty-nine of the farms had workstock, nine-tenths of which were horses, and approximately one-fifth of the farms raised colts. Hogs and beef cattle were of minor importance. Hogs were kept principally for home consumption. Brood sows were found on less than one-half of the farms, and on more than half of them hogs or pigs were purchased for home consumption. Four percent of the farms had beef cattle.

TOPOGRAPHY, EROSION, AND CROP ROTATION

An indication of the crop rotation or land-use relationships for the area was obtained by noting the cropping procedure on 75 fields from sample farms. The fields were selected so as to be almost all limestone hill land. The average slope ranged from 5 to 30 percent or more. The slope on two fields ranged from 5 to 12.5 percent; on 16 fields from 12.5 to 20 percent; on 48 or approximately two-thirds, 20 to 30 percent, and on nine, over 30 percent.

Both sheet and gully erosion existed in the area, but sheet erosion was much more apparent. On 63 of the 75 fields, or about four-fifths, 25 to 75 percent of the surface soil had been washed away, and there had been some loss of subsoil. Less than 25 percent of

the surface soil had been washed from six of the remaining fields, and on the six others more than 75 percent of the surface soil had been removed and also much of the subsoil. On 38 of the fields with slopes ranging from 20 to 30 percent, 25 to 75 percent of the surface soil had been removed; on four, less than 25 percent, and on six, more than 75 percent had been removed. There was little or no relationship between slope and erosion, as approximately the same amount of erosion was found on slopes of 20 percent or less as on those of 20 to 30 percent or more.

Table 2. Relation of crop rotation to yield. 1916 to 1935.

Length of rotation	Average length	Number of fields	Yield per acre		
			Corn	Tobacco	Alfalfa
years	years		bushels	pounds	tons
2- 5	3.4	5	26.2	550	—*
6-10	7.5	18	31.5	697	2.2
11-17	13.5	9	37.5	922	1.7

* No alfalfa was grown on the fields in this group.

The 32 fields on which data from complete crop rotations were obtained were divided into three groups, based on the length of rotation. The average yields of corn, tobacco, and alfalfa for each group are shown in table 2. There is a direct relationship between length of rotation and yields, the yields of corn and tobacco being higher in the longer rotations. The kind of crop grown, alfalfa in particular, largely determined the length of the rotation. The cropping procedure on farms with the shortest rotations was to grow corn or tobacco followed by wheat, and then a grass- and-legume mixture for one to three years. Sweet clover, red clover, and lespedeza were the legumes used in the shortest rotations. On half the fields with 6- to 10-year rotations, alfalfa was cut for four to eight years or until bluegrass took its place. On three fields, alfalfa was used in a mixture with orchard grass, bluegrass or timothy, for both hay and pasture. On the 9 fields with rotations ranging from 11 to 17 years, alfalfa was grown alone or with bluegrass and orchard grass, on all the fields except one which had bluegrass alone. It was used for hay until bluegrass took its place, after which the field was used for pasture. The yields of alfalfa on the

longest rotations were not as large as on the shorter ones, probably because it was harvested for hay over a longer period before the fields were used for bluegrass pasture.

The 43 fields on which data from complete rotations were not obtained usually had been cleared of either woods or bushes and one or two cultivated crops (corn or tobacco) had been produced, followed in order by small grain, alfalfa for hay, and then bluegrass until the year of the field study, 1935. For this reason, the length of rotation for all the fields could not be obtained. Also, in a few instances, the complete rotation data were not available because the operator had only recently moved on the farm.

Wheat, oats, and rye were used as cover and nurse crops on 72 of the 75 fields, following a cultivated crop of corn or tobacco. Wheat, the most common small-grain crop, was seeded on 43, or about three-fifths, of the fields. Oats seeded in the spring were used as a nurse crop, principally for alfalfa, on 26, or approximately one-third, of the fields, while rye was used as a nurse or cover crop on only three.

On fifteen of the 75 fields, histories of two complete rotations were obtained; on four fields, three; on one, four; and one, five. Alfalfa was found in about two-thirds of the second, third, fourth, and fifth rotations, while in the first rotations, sweet clover or a mixture of sweet clover and orchard grass and timothy was more prevalent.

PASTURE MANAGEMENT

It has been shown that about two-thirds of the total acreage in farms was used for pasture. With this proportion of the land in pasture, it is important to consider the pasture management practices in some detail.

Permanent, rotation, temporary, and brush or woodland pastures were found on the 94 farms in the study. More than half of all the pasture was classed as "permanent" and consisted principally of bluegrass. The "permanent" pasture generally is part of a very long rotation in which the field is pastured 10 to 20 years. The procedure usually followed for establishing a permanent pasture was to sow wheat, oats, or rye after a cultivated crop, the small grain being used as a nurse crop for the grasses and legumes seeded

either in the fall or spring. After the hay crop was harvested for one to four years, the grass and legume mixture was usually turned into permanent pasture.

Rotation pasture, usually a mixture of legumes and grasses, followed a year or two of mixed clover hay crops with pasture following for one to three years. The acreage used for temporary pasture, principally small grain used as a cover or nurse crop, was small. The hay crops were sometimes pastured for a short time in the early spring and after mowing in the fall, but many farmers objected to pasturing either the small grain or hay crops. The reason usually given was that the character of the soil was such that puddling or packing took place with grazing, particularly in the early spring. Brush pasture included a little less than one-fourth of the total pasture acreage. Usually this type of pasture consisted of bluegrass and bushes on badly washed land in various stages of reclamation. Woodland pasture usually consisted of small patches of locust thickets or other second-growth trees. There was an average of approximately five acres of total pasture for each animal unit on the 94 farms[1].

LAND TENURE

Five out of every six farms in the area were operated by the owners, but twenty of these owner-operated farms had croppers who produced tobacco or corn and sometimes wheat and hay crops on the share. The owner operators furnished the land, team, tools, and most of the seed, while the share-cropper produced the crops under the general supervision of the owner. The crops were usually grown on the half share. Fifteen of the owner operators were owners who owned a part and rented, usually on half share, additional land. On five of these 15 part-owner farms some of the crops were produced by croppers on share.

VALUE OF INVESTMENT

The estimated value of the investments in farm real estate, livestock, machinery, equipment, and supplies, averaged $4,700 for the 94 farms. The value ranged from $971 to $9450 and about

1 An animal unit is one horse, mule, or cow, two colts or heifers, four calves, one bull or steer, seven sheep, 14 lambs, five hogs, 10 pigs, 100 chickens or 50 turkeys.

half the farms had investments between $3000 and $5000. Eighty-two percent of the investment was real estate, 15 percent livestock, and the remaining three percent machinery, equipment, and supplies. The investment in machinery and equipment averaged $129 per farm and consisted principally of a mower, rake, sled, harness for two horses, hillside breaking plow, one-horse double shovel, A-harrow, disk harrow, a few hand tools, and in most cases a wagon. Supplies on hand were largely corn and hay averaging $32 in value on March 1.

The amount of indebtedness was ascertained from 63 of the 94 farms. Debts on 37 farms averaged $1597 per farm or about two-fifths of the estimated value. On 26 farms no debts were reported.

FARM RECEIPTS

The farm receipts of the 94 farms averaged $804; approximately one-fourth had less than $500, one-half between $500 and $1000, and the remaining one-fourth more than $1000. About two-thirds of the total receipts were from livestock and livestock products, and nearly one-third from crops, table 3. Lambs and wool, dairy and poultry products, and cattle sales (mostly veal calves) were the principal sources of livestock income. Most of the income from crops was from tobacco, which amounted to about one-fifth of the total receipts.

Table 3. Average receipts per farm for 94 farms, in 1935.

Item	Dollars	Percent of total
Tobacco	159	19.8
Other crops	90	11.2
Dairy products	123	15.3
Cattle	73	9.1
Sheep	185	23.0
Hogs	15	1.8
Poultry	103	12.8
Horses	11	1.4
Increase in feed and supplies	8	1.0
All other	37	4.6
Total	804	100.0

FARM EXPENSES

The total expenses of the 94 farms averaged $339, and 58 farms had expenses ranging between $200 and $500, table 4. The cropper

labor expense is the amount the share cropper received for the crops produced on shares.

Table 4. Average expenses per farm for 94 farms, in 1935.

Item	Dollars	Percent of total
Hired labor	20.90	6.2
Cropper labor (tobacco)	15.63	4.6
Cropper labor (other crops)	22.70	6.7
Unpaid family labor	61.00	18.0
Feed (grain and mill feeds)	24.89	7.3
Feed (hay)	7.05	2.1
Repairs to buildings and fences	9.36	2.8
Seed	13.25	3.9
Insurance	14.34	4.2
Taxes	33.75	10.0
Depreciation	56.00	16.5
All other	60.13	17.7
Total	339.00	100.0

The item "all other" includes the cost of automobile and telephone for farm use, breeding fees, machinery repairs, hauling farm products to market, and other miscellaneous farm expenses. Unpaid family labor and depreciation are non-cash expense items which are included in order to compare the farms and farm operators with one another.

FARM INCOME, LABOR INCOME AND FAMILY LIVING

The difference between the average receipts and the average expenses was $465, table 5. This amount was available for family purchases and interest and debt payments or savings. Where no debts existed, the total amount was available for family purchases or savings. The farm incomes for the 94 farms varied from a loss of $3 to a gain of $1471, and most of the incomes ranged from $300 to $800.

In order to place all farms on the same basis, interest at five percent on the total value of each farm investment was calculated and the amount deducted from the farm income. The remainder represents the return for the operator's labor and management. The average return was $230 for the 94 farms. Most of the farms had labor incomes between $100 and $600.

In addition to the labor income, each farm furnished a signifi-

cant amount of non-cash items that contributed to the family living on the farm. The estimated cash value of these was $373. A garden, hogs for meat, and poultry and dairy products were the principal items. In estimating their value the market value at the farm was used. House rent value was estimated at ten percent of the value of the house. The average value of family living added to the average labor income totaled $603. Thus, the average farm operator had earnings amounting to approximately $603 after allowing five percent for interest on the total investment. The labor income was $230 and family living $373.

Table 5. Average labor income, value of family living, and operator's earnings for 94 farms, in 1935.

Item	Dollars	
Average receipts per farm	804	
Average expenses per farm	339	
Farm income		465
Interest on investment ($4700 @ 5%)		235
Labor income		230
Family living furnished by the farm:[1]		
Garden	71	
Other crops	2	
Hogs	93	
Poultry and poultry products	44	
Dairy products	42	
Other livestock and livestock products	2	
Wood for fuel	29	
House, rent value	90	
Total		373
Operator's earnings		603

1 The garden averaged 0.7 acre; hogs, 936 lbs. live weight; poultry, 53 chickens and 122 dozen eggs; dairy, the equivalent of 436 gallons whole milk, and wood for fuel, 20 cords.

SIZE OF BUSINESS AND PROFITABLE FARMING

The size of the farm business is an important factor affecting the profits or losses in farming. A large business may increase the loss when prices of farm products or efficiency are low in relation to other prices or average efficiency. Under more favorable conditions, however, the larger farm business usually increases profits within certain limits. No single factor affords an accurate measure

of the size of the farm business. From the data of the 94 farms it is apparent that productive man-labor units, productive animal units, acres in pasture, acres operated, acres in tobacco, total investment, and acres in legumes were size factors having a direct bearing on the profits of these farms.

The number of productive man-labor units probably was the best measure of size of business[1]. The range of productive man-labor units for the sixteen smallest farms was from 90 to 195 with an average of 156. The labor incomes in this group of farms averaged $74, and half of them were minus labor incomes. In the next smaller group of 31 farms, the productive man-labor units increased to an average of 231, while the average labor income more than doubled, averaging $151 with six of these farms having minus labor incomes. For the next 31 farms, the productive man-labor units increased to 307, and the average labor income increased to $271 with five having minus labor incomes. On the largest 16 of the 94 farms, the productive man-labor units increased to 418, and the labor incomes averaged $460. Only one in this group of largest farms had a minus labor income. The other size factors showed a similar trend when sorted into the same number of groupings. It should not be assumed, however, that a larger size of business as measured by acres operated, productive animal units, or productive man-labor units, is always a guaranty of higher labor income. Three in the group in which business was smallest according to these factors had above average labor incomes, and some of the farms in the group of largest business had below average labor incomes, indicating that factors other than size of business also affect the income.

PASTURE AND PROFITABLE FARMING

A high proportion of the farm land in open pasture resulted in increased profits. It has already been stated that the total acres operated was an important size factor affecting labor income. Therefore, before attempting to measure the effect of the proportion of the farm in open pasture upon income, the farms were divided

1 A productive man-labor unit corresponds approximately to the average amount of man labor accomplished in 10 hours in the production of crops, livestock, livestock products, or in labor off the farm.

into two groups; one in which the number of acres operated was 88 or less, and the other in which it was 89 or more. These two groups were then divided into three subgroups each, according to the percentage of acres operated in open pasture.

Of the 47 farms in the small-size group, 13 had less than 35 percent of the acreage operated in open pasture, and 7 of these had minus labor incomes. The 13 farms averaged $56. Seventeen of the farms had between 35 and 55 percent in open pasture, and their average labor income was $80; only three had minus labor incomes. Also, 17 of the farms had 55 percent or more in open pasture. The average labor income of this group was $226, while only four had minus labor incomes. The entire group of 47 farms had an average of 68 acres and made an average labor income of $126.

In the large-size group, 9 farms had 35 percent or less of the acreage in open pasture, and three of these had minus labor incomes. Sixteen farms had from 35 to 55 percent in open pasture, and only one had a minus labor income. Twenty-two of the farms had 55 percent or more in open pasture, and only two of these had minus labor incomes. The labor incomes were $159, $356, and $364, respectively, for the three subgroups. This group of 47 farms had an average of 117 acres and the labor income averaged $322. It should be noted that, in both size groups, as the percentage in open pasture increased the percentage of tillable land in corn decreased.

RECEIPTS PER PRODUCTIVE ANIMAL UNIT AND PROFITABLE FARMING[1]

Getting more than average receipts per head of livestock was another major factor for increased profits. It has been stated that the number of productive animals is one of the measures of size of farm business. In view of the effect of size on profits, the farms were divided into two groups with 9.7 or less productive animal units in one group and 9.8 or more in the other. Both groups were then subdivided into three divisions according to the livestock receipts per productive animal unit.

In the group with 9.7 or less, 12 farms having a range of $0 to

1 One cow, 7 ewes, 100 hens or 5 sows are the equivalent of one productive animal unit.

$40 receipts per productive animal unit had minus labor incomes. The average labor income for the 16 farms in this range was minus $24. The next 20 farms in this group with a range of $41 to $60 per unit had an average labor income of $134, and three of these farms had minus labor incomes. The 12 farms with a range of $62 to $103 per unit, averaged $186, and two of them had minus labor incomes.

The group of farms with 9.8 or more productive animal units per farm had 12 farms with receipts per unit ranging from $0 to $40, two of which had minus labor incomes. The average labor income was $155. The receipts per unit on 22 of the farms ranged from $41 to $60; the average labor income was $342. One farm had a minus labor income. The receipts per unit for the 12 highest farms in this group ranged from $61 to $92 per unit, the average labor income was $642; there were no minus labor incomes.

Altho high receipts per head of livestock are an important factor in increased profits in most cases, it is not always so. For example, on one farm in the group of 48 with less than 9.7 productive animal units per farm the receipts per unit were $193 and yet the labor income was minus $117. On another farm in this group the livestock receipts per productive animal unit were $39, and the labor income was $171. However, other factors being equal or average, the labor income in this area generally varied directly with the number of productive animal units per farm and the livestock receipts per unit. The principal productive livestock on these farms were dairy cattle, sheep, and poultry (including turkeys). The principal factors contributing to higher receipts per productive animal unit for these livestock were the pounds of milk or butterfat sold per cow, pounds of lamb sold per ewe, and number of eggs sold per hen.

COMBINED EFFECT OF IMPORTANT FACTORS ON PROFITABLE FARMING

A very significant fact brought out was that maximum profits are much more dependent upon the business being strong in several major factors of profit rather than in only one. The effect of different combinations of the factors, (A) productive man-labor

units, (B) proportion of open pasture, and (C) receipts per productive animal unit, when they were above or below the average, is shown in table 6. The profits were highest when all the factors were above the average. In all cases the labor income varied within the group of farms in relation to the extent which all or a part of the three factors were found to be above or below the average. The analysis indicates that these factors are the three most important independent variables for these farms.

Table 6. Effect of three factors on farm profits[1]. 1935.

Factors above average	Number of farms	Labor income	Operator's earnings
		dollars	dollars
None	21	27	332
B	7	94	367
C	8	138	497
A	9	161	549
A, B	13	217	656
B, C	11	322	663
A, C	8	420	888
A, B, C	17	479	903

1 A, Productive man-labor units; B, Percent of farm in open pasture; C, Receipts per animal unit.

The percent of the farm in open pasture was less important than either of the other two factors, in directly determining labor income, tho it may have been very effective in increasing the receipts per animal unit and also may have influenced the number of productive man-labor units. Productive man-labor units were the most important single factor in determining labor income. Factors in association had the same relative effect as when alone. The 17 farms with all three factors above the average made labor incomes approximately 18 times those of the 21 farms with all three factors below the average.

Seven of the 17 farms with all three factors above the average were 10 percent or more above the average in productive man-labor units, percent of farm in open pasture, and receipts per productive animal unit. These seven farms made an average labor income of $716 and the operator's earnings averaged $1147.

LAND MANAGEMENT PRACTICES AND FARM PROFITS

The 94 farms contained 85 percent or more of limestone hill land and less than 8 percent bottom or level land. General observations, and tests on 100 farm fields, showed that considerable erosion had taken place on practically all farms in the area. In view of this situation it becomes highly desirable to consider practices that are helpful in converting eroded land to profitable use and to test the type of land management that has been found to be most profitable.

For the purpose of measuring some of the outstanding land-use practices in regard to the effect they had on farm profits, a land-management score card was made. The important land management practices considered were: (1) ten percent or less of tillable land in cultivated crops; (2) winter cover crop on all intertilled land; (3) eight percent or more of the tillable land in hay, pasture, or other soil-building crops; (4) ten percent or less of acreage operated in brush pasture; and (5) a seeding mixture including at least one grass and legume with or following all winter cover crops. Each farm was scored on these points and the total score for each determined its land management index. The average index for all the 94 farms was 100.

The 94 farms were divided into four groups according to their land-management index, table 7. The labor income of the 29 farms having an average index of 132.1 was more than three times as large as that of the 22 farms having an average index of 32.6.

Table 7. Influence of land-management index and various factors on labor income. 1935.

Land-management index		Number of farms	Percent open pasture	Receipts per P.A.U.*	Productive man-labor units	Labor income
Range	Average					
				dollars		dollars
0-60	32.6	22	33.2	42	245	93
61-99	80.5	22	44.6	49	271	191
100-122	111.0	21	55.9	56	312	304
123-222	132.1	29	57.5	53	274	311

* P. A. U. = Productive animal unit.

It should be noted, also, that a similar relationship is shown in the percent of the farm in open pasture, the receipts per pro-

ductive animal unit, and the productive man-labor units. This relationship probably existed because the practices included in the index have been used for many years and, therefore, have influenced the pasture acreage and kind of pasture, the kind and number of livestock, and the number of productive man-labor units. For example, a winter cover crop helps control erosion and, thereby, aids in increasing the yields of future crops. Probably it also helps protect the grass, legume, or mixture seeded in or with it. These soil-building crops maintain fertility and add organic matter to the soil. The topography of this area is such that it is practically impossible to cultivate the land often and maintain fertility. Erosion was probably greater and yields of all crops were less on farms with relatively short rotations as was shown in table 2. Brush pasture was less profitable than open bluegrass pasture according to practically all the farmers interviewed. Brush or small bushes furnished very little nutritive pasture for livestock, but shaded the land and used the moisture and plant food which otherwise could have been used by the legumes and grasses.

FARMS WITH MORE THAN EIGHTY-FIVE PERCENT OF LIMESTONE HILL LAND AND EIGHT PERCENT OR MORE OF BOTTOM

The yield of corn on the 26 farms with eight percent or more bottom land was approximately 20 percent larger than that on the 94 farms with less than eight percent, and an average of 50 percent more brood sows were kept. The total acreage operated was slightly less than the average. The important factors affecting farm organization and farm profits on these farms are shown in table 8, and the 10 with higher labor incomes in this group are compared with the average of the 26 farms. A study of these factors indicates that size of business and efficiency in production were the most important factors affecting income. The 10 farms with high labor incomes had approximately 25 percent more animal units per farm and received $13 more per animal unit than the average of the 26 farms. The receipts per cow for the 10 high farms were approximately 20 percent larger than the average. The 10 high farms also did approximately 10 percent larger businesses as indicated by acres operated

and man-labor units, and the labor income was more than twice as much as the average.

Table 8. Average of 26 farms with more than 85 percent of limestone hill land and eight percent or more bottom, and of 10 farms having high labor incomes. 1935.

Important factors	26 farms	10 farms
Productive man-labor units	280	313
Acres operated	76	82
Productive animal units	8.7	10.6
Acres open pasture	32	32
Receipts per ewe, dollars	6.25	6.16
Receipts per cow, dollars	52	62
Ratio of animal units to acres open pasture	3	3
Percent of farm in open pasture	42	39
Percent receipts from dairy cattle and sheep	40.4	38.8
Livestock receipts per productive animal unit, dollars	61	74
Animal units per 100 acres	11	13
Productive man-labor units per man	195	215
Percent of farm bottom land	19.1	18.8
Average labor income, dollars	293	603
Average operator's earnings, dollars	636	952

FARMS WITH SEVENTY TO EIGHTY-FIVE PERCENT OF LIMESTONE HILL LAND

The 14 farms with 70 to 85 percent of limestone hill land were analyzed separately from the other 120 farms. The average percent of limestone hill land was 79 as compared with 96 percent for the 120 farms. Ninety-two percent of the land was classified by the farm operators as steep, 21 percent as rolling, and 7 percent, level or bottom land. There was considerable similarity in the farm organization of the farms with 70 to 85 percent limestone land and those with from 85.1 to 100 percent, table 9. The 14 farms with 70 to 85 percent limestone land were approximately 16 percent larger, however, as measured by the number of acres operated, and about 10 percent more productive man-labor units were required for their operation. These farms also were larger according to productive animal units and received an average of approximately one-third more income from each productive animal unit. The 14 farms received a greater percent of the total receipts from poultry and a smaller percent from dairy cattle and sheep. The other factors compared were relatively the same, as shown in table 9.

Table 9. Average of 14 farms with 70 to 85 percent of limestone hill land, and of 94 farms with more than 85 percent. 1935.

Important factors	94 farms	14 farms
Productive man-labor units	275	303
Acres operated	93	110
Productive animal units	10.2	10.8
Acres open pasture	45.6	55.1
Receipts per ewe, dollars	6.47	7.27
Receipts per cow, dollars	46	55
Ratio of animal units to acres open pasture	4.5	5
Percent of farm in open pasture	49	50
Percent receipts from dairy cattle and sheep	47.4	40.8
Percent receipts from poultry	12.8	19.8
Percent receipts from tobacco	19.8	19.9
Livestock receipts per productive animal unit, dollars	49	68
Productive animal units per 100 acres	10.9	9.9
Productive man-labor units per man	200	217
Average labor income, dollars	230	397
Average operator's earnings, dollars	603	761

SUMMARY

The limestone hill-land farms are in a region fairly well adapted to the production of grass for livestock and of most of the crops grown in the North Central States, especially burley tobacco and lespedeza.

The lay of the land and condition of the soil are the principal influences affecting the type of farming on the limestone hill land.

More than nine-tenths of the land is classed as steep or rolling. Because of this condition, a cultivated crop cannot be grown very often if the fertility of the soil is maintained and erosion is controlled in a practical way.

The data obtained indicate that the acreage operated most profitably ranged from 90 to 150 acres, and the productive man-labor units on the most profitable farms ranged from 300 to 500. Farms with 300 units provide full-time employment for one man and half time for another. Those with 500 units provide full-time employment for two men and half time for another.

The land was utilized most profitably when approximately one-sixth of the acreage was used for the production of alfalfa hay, from one-half to two-thirds for open pasture, less than one-tenth for

brush pasture, and one-tenth or less of the tillable land for intertilled crops.

The rotation of crops most suitable for the limestone hill land farms was a cultivated crop, usually corn or tobacco, followed by a cover crop of wheat or rye. A mixture of a legume and grass, usually alfalfa and orchard grass, was seeded in the cover crop. The alfalfa and orchard grass was cut for hay for four or five years, and then pastured for four or more years before it was plowed again for an intertilled crop.

Two-thirds to three-fourths of the total farm receipts were from the sale of livestock and livestock products. Dairy cattle and sheep were the most important livestock since they are grass and roughage consuming and consequently utilize the crops best suited to the farm land. The crops produced do not require a large amount of labor, except tobacco, and this crop is usually limited to a few acres. Dairy cows are preferable to sheep since they return more income for the amount of feed and pasture used, and usually labor is available for the additional work that dairying requires.

In this area a considerable portion of the farm operator's time is wisely spent in producing a good supply of food for his family. As a result of the natural conditions that influence the farming practiced in the area, the production of an ample supply of garden and truck crops to supply fresh vegetables and sufficient quantities for canning for home use is highly desirable. In addition, the production of milk and milk products, poultry and poultry products, and in many cases the entire meat supply for the family is advantageous.

Tobacco produced for the most part by the operator's own family labor is usually profitable provided it does not interfere too much with the necessary work in connection with the livestock kept. In many instances, especially where the amount of land to be plowed for intertilled crops is limited, it may be desirable to grow an additional acreage of tobacco, instead of all the corn required for livestock, especially if tobacco prices are expected to be favorable and the land will produce tobacco of high quality.

Kentucky
Agricultural Experiment Station

University of Kentucky

FACTORS AFFECTING THE PLACE OF SHEEP ON KENTUCKY FARMS

BULLETIN NO. 385

Lexington, Ky.
September, 1938

SUMMARY

Spring lamb production is an enterprise well adapted to a large number of Kentucky farms. The crop-specialty—grazing type of farming followed on a large part of the commercial agricultural land requires a comparatively large acreage of pasture and hay land. In parts of the state where the proportion of land in pasture has increased, the number of sheep also has increased.

Records of expense and income for flocks in the Inner Bluegrass Area and Owen County, for 1932 thru 1936, and Meade County for 1933 thru 1936 showed that feed and pasture represented 55 to 60 percent of the gross cost; depreciation of ewes, 15 to 17 percent; labor, 6 to 9 percent, and other items such as interest, taxes, rams, shelter, equipment, veterinary fees, medicine, salt, shearing and trucking, 14 to 24 percent.

Lambs represented 80 percent; wool, 18 percent and manure, 2 percent of the total income.

Differences in pounds of lamb produced per ewe, price received for lambs, and pounds of wool produced per ewe accounted for differences in income. Cost of harvested feed, depreciation of ewes and a few minor cost items made up the differences in cost per ewe.

The place of sheep in the organization of the farm was determined by the income from them and their utilization of the available feed, labor, shelter, and other production factors, in relation to the other farm enterprises.

On the Inner Bluegrass and Meade County farms, sheep furnished about 10 percent of the total farm income; on the Owen County farms they furnished about 20 percent.

Sheep required most labor during January, February and March, in the Inner Bluegrass Area and Owen County, and the demand continued thru April in Meade County.

The sheep enterprise provided an income from buildings and equipment which otherwise might not have been fully used. Sheep also increased the farm earnings by controlling weeds in seed and hay crops.

In deciding whether or not the sheep enterprise will increase the farm earnings, it is necessary to determine how well the nonmarketable feeds, the available man labor, and tobacco barns, or other buildings that would provide shelter for sheep, are being utilized. If additional pasture, other nonmarketable feeds, labor and shelter are available on the farm, sheep will increase the earnings of the farm by the amount that the receipts from the sheep exceed the value of marketable feeds, interest, depreciation and cash expense for the sheep.

Bulletin No. 385

FACTORS AFFECTING THE PLACE OF SHEEP ON KENTUCKY FARMS

GEO. B. BYERS and D. E. BAYLESS[1]

INTRODUCTION

The production of spring lambs is an enterprise well adapted to a large number of Kentucky farms. The climate of the State is mild; it has abundant pastures and it is near the consuming areas of the United States. These natural advantages encourage farmers to raise spring lambs.

A large part of the commercial agricultural land area of Kentucky is adapted to a crop-specialty—grazing type of farming. Burley tobacco, by virtue of its high value and its adaptability to the soil, topography, climate and social and economic conditions, is produced on more farms than any other single commercial crop in the state. Long experience in growing burley tobacco has demonstrated that it is wise land use to keep as much as possible of the land in a sod crop. Similarly, the more successful farmers have observed that land from which tobacco and other cultivated crops are harvested should be seeded to a winter cover crop in order to reduce soil erosion and prevent leaching of plant food. These practices give rise to one of the most important problems of this type of farming—economical utilization of available pasture.

The use of sheep in this type of farming is to consume a relatively large amount of roughage, particularly pasture, and a relatively small amount of grain, as compared with other kinds of livestock. In order to determine whether or not sheep have a place in the agriculture of an area it is necessary to consider both their income possibilities and the cost of their feed and care. This bulletin gives the lamb and wool production, the feed, labor and other production requirements, and the methods of flock management practiced by the cooperating farmers under actual farming conditions. During one or more of the five years (1932 to 1936) 47

1 The authors wish to acknowledge the valuable assistance of Mr. A. B. Poundstone who organized the sheep project for the Inner Bluegrass Area. Statistical workers assigned by Federal Works Progress Administration rendered valuable assistance on graphs and tabulations. Mr. Bayless was formerly assistant in farm management in the Kentucky Agricultural Experiment Station.

farmers located in parts of Bourbon, Clark, Fayette, Harrison, Jessamine, Scott and Woodford Counties which are typical of the Inner Bluegrass Area, furnished detailed cost of production records of their sheep flocks. For the same period, 111 farmers in a part of Owen County typical of the Outer Bluegrass Area furnished similar records. During one or more of the four years (1933 to 1936) 18 farmers in that part of Meade County included in the Eastern Pennyroyal and Knobs type-of-farming area cooperated in this project.

The farmers who cooperated in the study made an effort to improve their methods of sheep production, as is shown by a comparison of the net return of the flocks of these farmers with the return of the flocks of the other farmers who had sheep, in the same community.[2] For example, twenty-three Owen County farmers kept detailed production figures of their flocks in 1933. The same year 76 other farmers gave survey reports of their sheep production data. The 23 farmers received 80 cents per ewe, or $40 per flock, more in net returns than the 76 farmers. It is believed that a similar difference in earnings existed between the farmers cooperating in this study and all other farmers in the Inner Bluegrass Area and Meade County. The results obtained by the cooperating farmers offer a means of determining the place of the sheep enterprise in profitable farming.

NUMBER OF SHEEP AND PASTURE AREA

In considering the choice or change of a farm enterprise it is well to study the shifts that have been made by the farmers in the particular type-of-farming area in order to determine the general trend of the enterprise. An indication of shifts in livestock may be obtained by examining the number for each census period. Since 1900, the number of sheep for the Inner Bluegrass Area and for Owen and Meade Counties has increased (figure 1)[3]. For the Inner Bluegrass Counties the range of increase for individual counties was two to four times the number in 1900, and in Owen County the number more than doubled. The number of sheep in Meade County

2 Sheep enterprise survey of Jonesville Community, Owen County, Kentucky.

3 Some changes in numbers have resulted from changes in date of enumeration. For example, from 1870 to 1900, inclusive, the date of enumeration was June 1; in 1910 the date was April 15; in 1920, 1925, and 1935, January 1, and in 1930, April 1. An attempt has been made to adjust for the difference due to enumeration dates by using the number of ewes one year old or older.

fluctuated but increased about one-fifth from 1900 to 1935. The rapid increase in the number of sheep in areas naturally adapted to pasture production, particularly bluegrass pasture, indicates that available pasture is an important factor influencing the number of sheep. It is recognized, however, that other kinds of livestock compete with sheep for the use of pasture.

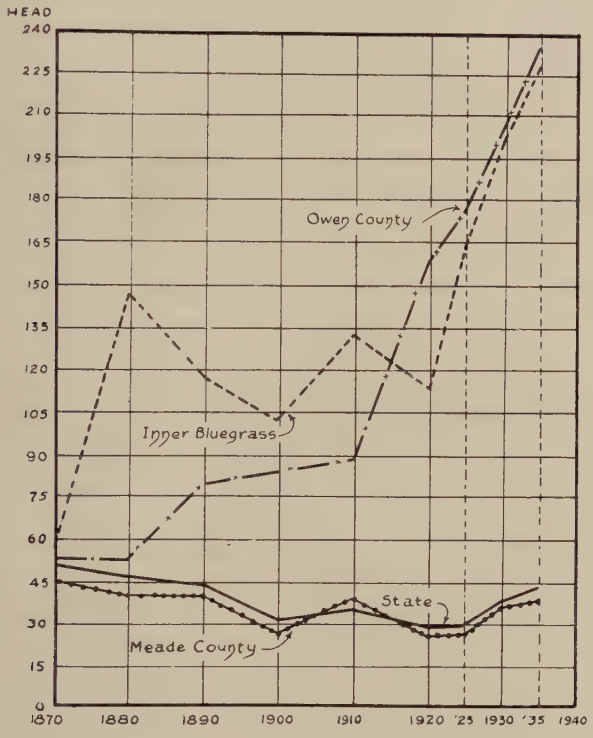

FIGURE 1. The number of head of mature sheep per thousand acres of land, by Census periods, for the Inner Bluegrass Area, Owen County, Meade County, and the State.

The proportion of improved farm land in pasture, including plowable pasture, has increased to a marked degree in the Inner Bluegrass Counties (figure 2). A comparison of figures 1 and 2 shows the rapid increase in percent of improved farm land in pasture to be accompanied by a rapid increase in the number of sheep in the Inner Bluegrass Area. Owen County showed a similar relationship between number of sheep and percent of improved farm land in pasture, until 1925, after which the number of sheep continued to

increase but the percent of improved land in pasture decreased. This decrease in improved farm land in pasture was caused, evidently, by a shifting of improved farm land to non-plowable pasture land, since the acreage of non-plowable pasture land increased.

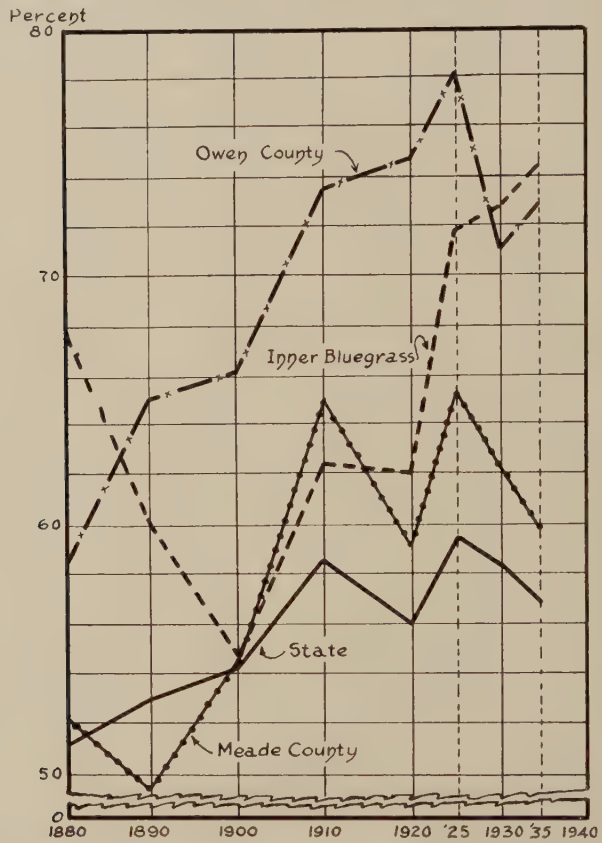

FIGURE 2. The percent of improved farm land in pasture, by Census periods, for the Inner Bluegrass Area, Owen County, Meade County, and the State.

This increase in non-plowable pasture acreage linked with an increased acreage of harvested hay land very probably made it possible for the farmers to continue to increase their number of sheep after 1925 even tho the percent of improved farm land in pasture decreased. Meade County showed little relationship between pasture shifts and changes in the number of sheep. This was due largely

to a type of farming in which other kinds of livestock were relatively more important.

When comparing trends in the number of sheep in relation to pasture acreage, it should be kept in mind that small-grain pasture was not included. This acreage was more important as available pasturage in the Inner Bluegrass Counties than in either Owen or Meade County. Furthermore, the bluegrass and white clover pasture of the Inner Bluegrass Counties made sufficient growth for ample grazing earlier in the spring and later in the fall than it did in Owen or Meade County.

SEASONAL PASTURE GROWTH AND LAMB MARKETING

Spring lamb production, because of the comparatively short period required to grow the lambs for market, offers an economical means of using the pasture during its peak of growth. The spring lambs provide the necessary additional grazing animal units during that part of the spring and early summer when pasture makes its most luxuriant growth, figure 3.

To utilize fully the spring pasture the lambs must be produced early and have sufficient growth in order to do considerable early grazing. This makes for good quality of the lambs in two ways: first, it offers a good, luxuriant pasture and cool weather for the grazing period; second, the early lambs have less probability of

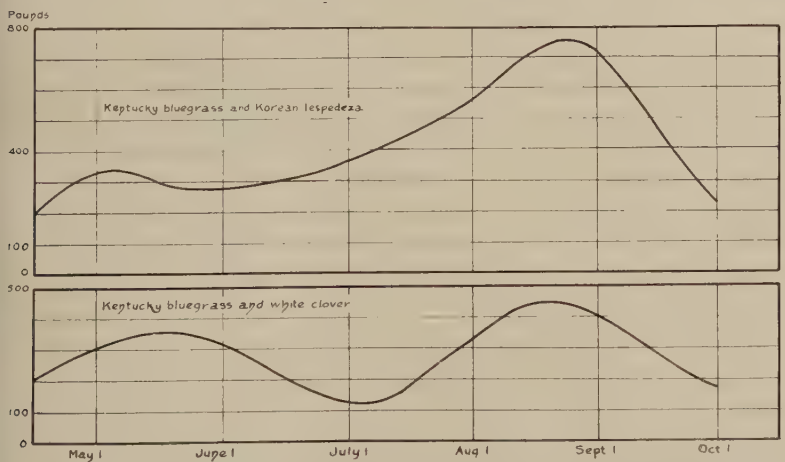

FIGURE 3. Seasonal production of pasture mixtures, in pounds of dry matter per acre at Lexington, for 1933 to 1935, inclusive. By courtesy of Dr. E. N. Fergus, Department of Agronomy, Kentucky Agricultural Experiment Station.

parasitic infestation. In addition to these natural advantages the price is generally highest when these high-quality lambs are ready for market[4] (table 1).

Table 1. Monthly average price for top lambs at Cincinnati during 1932 thru 1936.[1]

Year	April	May	June	July	August	September	October
	dollars	dollars	dollars	dollars	dollars	dollars	dollars
1932	10.10	7.68	7.25	7.00	6.53	6.30	5.40
1933	7.97	7.87	7.89	7.65	7.79	7.36	6.90
1934	7.77	10.50	9.00	7.75	7.29	7.03	6.45
1935	7.75	8.40	8.39	7.75	8.89	9.18	9.37
1936	13.44	12.56	11.78	9.93	9.50	10.09	8.85
Av. for 5 yrs.	9.40	9.40	8.86	8.02	8.00	7.99	7.39

1 As reported in "Notes on Kentucky Agricultural Situation" prepared by the Department of Markets and Rural Finance, Kentucky Agricultural Experiment Station.

ITEMS OF COST AND INCOME IN THE PRODUCTION OF LAMBS AND WOOL

Flock management practices change from time to time, and cost and income constantly shift. The variation in items of cost and income make it impractical to present values for these items that will hold good for all times and conditions. The percentage relationship of one cost item, such as feed and pasture, depreciation, or labor, to the total cost, however, remained fairly constant from year to year.

Feed and pasture[5]. During the period of this study feed and pasture averaged about 60 percent of the gross cost, figure 4. The cost of such items as concentrates, harvested roughages and pasture differed within an area from year to year and from area to area. The average value of feed and pasture for Owen County was $3.83 per ewe per year for the five-year period, 1932 to 1936, (Appendix, table 11). This item varied from $3.39 per ewe in 1934 to $4.01 in 1933. For the Inner Bluegrass Area feed and pasture averaged $3.49 per ewe per year during 1932 to 1936, and ranged from $3.06 in 1934 to $4.40 in 1936. Feed and pasture in the Meade County

4 Ky. Agr. Exp. Sta. Bulletin 302, "Quality as a Factor in the Price of Kentucky Lambs," page 110.

5 Cash costs were used for purchased feed. The value of farm-grown feed was in line with market value for the particular kind and quality of feed. Pasture rates for each year were determined by the customary charge for pasture in the particular area.

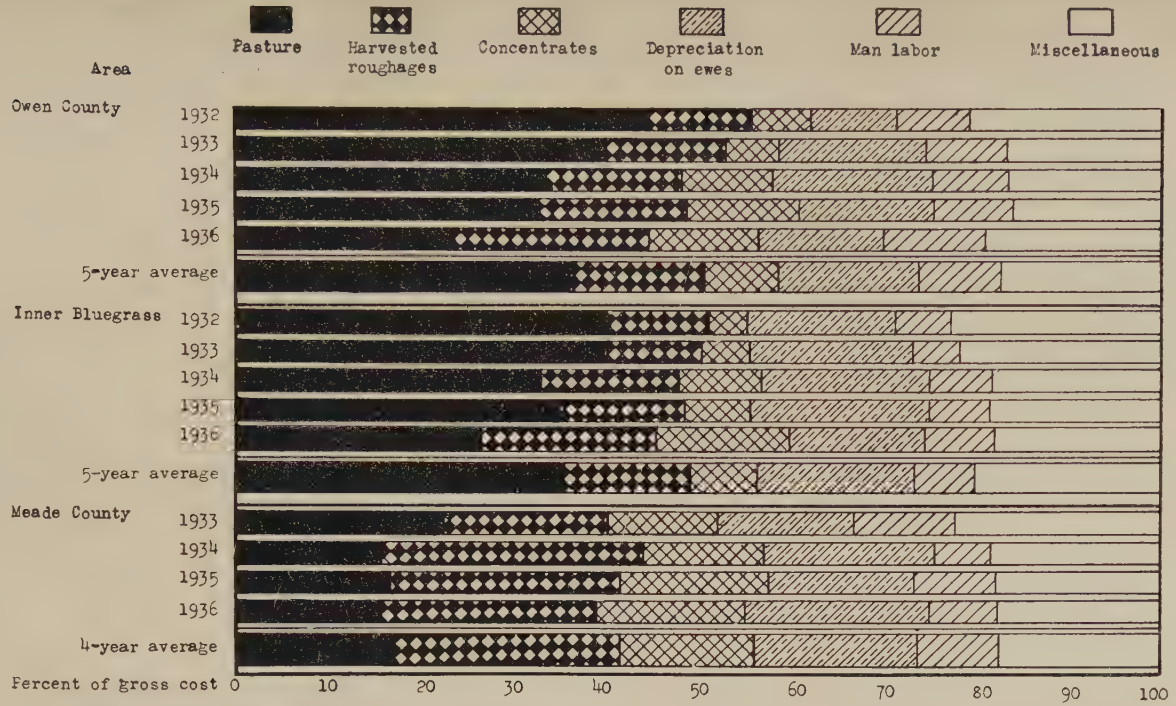

FIGURE 4. Relative importance of the items of cost in lamb and wool production, for the Inner Bluegrass Area, Owen County, 1932 to 1936, and Meade County, 1933 to 1936. "Miscellaneous" includes veterinary fees, medicine, salt, shearing, trucking, interest, taxes, cost of ram, shelter and equipment.

Area averaged $3.75 per ewe per year for four years, 1933 to 1936, and ranged from $2.82 in 1933 to $4.55 in 1935.

The Inner Bluegrass and Owen County flocks made greater use of pasture than the Meade County flocks as shown by eleven months of grazing per year in the former areas and only nine months per year in the latter. This difference in grazing time made necessary additional feeding of harvested roughage and concentrates for the Meade County flocks.

Variations in concentrate, harvested roughage and pasture costs from year to year may be seen by comparing 1936 with the other years, figure 4.[6] It should be kept in mind in this comparison that the long, severe winter of 1935-36, following a dry fall in 1935, made it necessary to feed harvested roughages earlier in the winter and to continue roughage and concentrate feeding much later in the spring of 1936 than usual. This difference was not so pronounced for the Meade County flocks because of their usual shorter pasture season.

Depreciation[7]. Depreciation was caused by age, injury, barren condition and death loss. It made up 15 percent of the gross cost for the flocks in Owen County and 17 percent for the Inner Bluegrass Area and Meade County.

Barren condition and injury such as spoiled udder increased the depreciation because, regardless of the age, the value of the ewe was reduced to fat-sheep value. The sale price of ewes influenced the depreciation, especially if a change occurred in market value during the year. Death represented a complete loss of the valuation of the ewe for the particular year in which the death occurred.

The amount of depreciation per year varied for different ages. The average value per head for the flocks in the study showed an increase from the age of lambs until two years old and a decrease after this age (Appendix, table 10). Based upon the percentage change which was determined from the value of these flocks, table 2

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6 A flock year as used here is a twelve-month period beginning September first and ending the following August thirty-first.

7 In order to obtain a depreciation charge that would represent an annual cost for the use of an ewe, it was necessary to eliminate from the inventory values the influence of a change in the market price of ewes during the year. This was done by holding the value constant for the same age in both the beginning and ending inventories. For example, yearling ewes on the beginning and ending inventories were given the same value. See appendix, Table 10, for the average value of ewes for each age group.

presents the value of ewes from one to eight years old when the value of yearling ewes ranges from $5.00 to $12.50 per head.

Table 2. Variation in the value per head of ewes according to age.

1 yr.	2 yrs.	3 yrs.	4 yrs.	5 yrs.	6 yrs.	7 yrs.	8 yrs.
dollars	dollars	dollars	dollars	dollars	dollars	dollars	dollars
5.00	5.25	4.75	4.00	3.25	2.50	1.75	1.25
5.50	5.75	5.25	4.50	3.50	2.75	1.75	1.25
6.00	6.25	5.75	5.00	3.75	3.00	2.00	1.50
6.50	6.75	6.25	5.25	4.25	3.00	2.25	1.50
7.00	7.25	6.75	5.75	4.50	3.25	2.25	1.75
7.50	7.75	7.25	6.25	4.75	3.50	2.50	1.75
8.00	8.25	7.75	6.50	5.00	3.75	2.75	2.00
8.50	8.75	8.25	7.00	5.50	4.00	2.75	2.00
9.00	9.25	8.75	7.50	5.75	4.25	3.00	2.25
9.50	9.75	9.25	7.75	6.00	4.50	3.25	2.25
10.00	10.50	9.75	8.25	6.50	4.75	3.25	2.50
10.50	11.00	10.25	8.50	6.75	5.00	3 50	2.50
11.00	11.50	10.75	9.00	7.00	5.25	3.75	2.75
11.50	12.00	11.25	9.50	7.25	5.50	3.75	2.75
12.00	12.50	11.75	9.75	7.75	5.75	4.00	3.00
12.50	13.00	12.25	10.25	8.00	6.00	4.25	3.00

Labor. Man labor cost[8] averaged 6 to 9 percent of the gross cost. Variations in the labor requirement were influenced largely by the length of the grain and roughage feeding period and the weather conditions during the lambing period. The lambing season and the winter feeding period occurred at approximately the same time and resulted in a peak of labor for the flock, figure 5. For the remainder of the sheep year the labor demand was light and fairly uniform.

Further study of the labor demands for sheep indicated that the work was divided into a number of seasonal jobs such as grain and roughage feeding, care of ewes and lambs during the lambing season, shearing and marketing lambs and wool, figure 6.

Miscellaneous cost items. Minor costs in the production of lambs and wool were interest[9], taxes[10], cost of ram[11], shelter and equip-

8 Labor costs were obtained by charging a flat rate of ten cents an hour for regular daily work. This rate approximated the going daily wage during the period of the study. Special labor such as castrating, docking, dipping, drenching, or shearing, when done with family labor, was also valued at ten cents per hour and included as man labor. If it was hired labor the actual cost was charged against the flock.

9 Calculated at six percent of the average yearly investment represented by the flock.

10 Half the beginning inventory value of the sheep was multiplied by the state tax rate of 50 cents for each $100 of assessed valuation.

11 Obtained by subtracting the gross receipts to the ram from the gross costs.

ment[12], veterinary fees, medicine, salt, shearing, and trucking[13]. The combination of all of these miscellaneous cost items amounted to 14 to 24 percent of the gross cost.

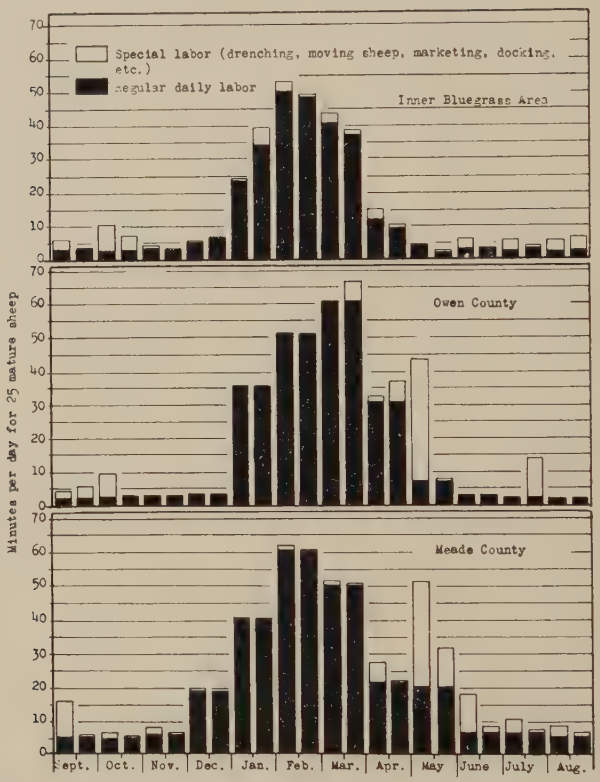

FIGURE 5. Seasonal distribution of man labor in caring for sheep. Inner Bluegrass Area and Owen County, 1932 to 1936; Meade County, 1933 to 1936.

Income. Lambs, wool and manure were the sources of total income from the sheep flock. The income from lambs made up about 80 percent of the total receipts during the period of this study, and from wool, 18 percent.

12 A total charge for buildings and equipment was calculated at ten percent of the replacement value for the proportionate part attributed to the sheep. The ten percent is assumed to cover depreciation, taxes, interest and upkeep for buildings and equipment.

13 The other minor items of cost were taken at their actual cash cost.

FLOCK MANAGEMENT AFFECTS PROFITABLE LAMB AND WOOL PRODUCTION

The profits or net returns to the sheep enterprise were influenced by flock management practices. To observe the effect of different practices, it seemed advisable to compare the more profitable with the less profitable flocks. In order to make this compari-

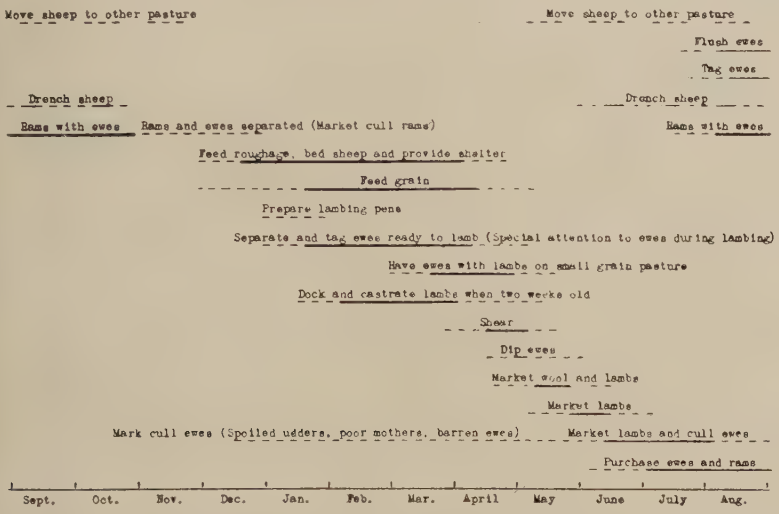

FIGURE 6. Periods of labor operations. A solid line represents the period when most farmers perform the operation; a broken line shows when some farmers performed it.

son, the third of all the flocks, each year, that made the highest net returns or profits per ewe was compared with the third that made the lowest net returns per ewe in the same year, table 3.

The knowledge that wide variation in net return existed between flocks in the same area and the same year, as well as in the same flock from year to year raised a question as to the cause of these differences. Differences in pounds of lamb produced per ewe accounted for the variation in income. Cost of harvested feed and depreciation made up the difference in the cost per ewe, figure 7.

Pounds of lamb produced per ewe. Number of lambs born, percent of lambs raised and weight of lambs when sold directly influenced the pounds of lamb produced per ewe. The factors influencing the pounds of lambs per ewe were in turn influenced by the sheep management practices followed by the farmers.

The number of lambs born per ewe was influenced by the age and condition of the ewes. No difference in productiveness that might be attributed to the breed of ewe was evident. The length of time that the lambs had been weaned, the amount of pasture available just before and during the breeding season, and the degree of internal parasite infestation were some of the factors in addition to age that influenced the condition of the ewes.

Table 3. Variation in net return, cost and income per ewe for Inner Blue Grass Area, Owen County and Meade County Flocks.

	Inner Bluegrass Area 1932 to 1936		Owen County 1932 to 1936		Meade County 1933 to 1936	
	High[1]	Low[2]	High[1]	Low[2]	High[1]	Low[2]
Number of flock years[3]	62	62	70	70	19	19
Average number of ewes per flock	88	90	46	47	34	35
Total income per ewe, dollars	10.11	7.71	8.82	6.35	10.79	7.26
Total cost per ewe, dollars	5.96	6.73	6 08	7.08	6.03	7.42
Net return per ewe, dollars	4.15	.98	2.74	—.73	4.76	—.16
Total difference per ewe, dollars	3.17		3.47		4.92	

1 One-third of the flocks each year with the highest net returns per ewe.
2 One-third of the flocks each year with the lowest net returns per ewe.
3 A flock year as used here is a twelve-month period beginning September first and ending the following August thirty-first. Where records were kept on the same flock for more than one year, as many flock years accrued to the flock as there were yearly records.

The largest number of lambs was born in flocks in which two-thirds or more of the ewes were two to six years of age. Two practices were used, in most cases, by these farmers, in keeping a large proportion of their flocks two to six years old: first, the older and more inferior ewes were replaced with good, young western ewes; second, others replaced the inferior and cull ewes each year with lambs. The farmers often expressed the opinion that lambs proved satisfactory, only if the best early spring lambs were kept.

The maximum pounds of lamb per ewe depended on the percentage raised of the lambs born. During 1935 and 1936, cooperators found that 50 to 80 percent of death losses were lambs born weak, born dead, starved, chilled or frozen. Rickets, deformity, tetanus, accidents, dogs, and parasites were, for the most part, the causes of the other deaths. Birth of dead or weak lambs was caused by the lambs being too large, the ewes being old or culls in poor condition, twins, triplets or born premature which was

sometimes caused by crowding the ewes just prior to the lambing season. Death of ewes, spoiled udders, old or cull ewes in poor condition, strayed lambs, disowned lambs, twin lambs or triplets caused lambs to starve. The loss from chilling or freezing was reduced by the more successful farmers by added care and better housing of the ewes and lambs during the lambing season.

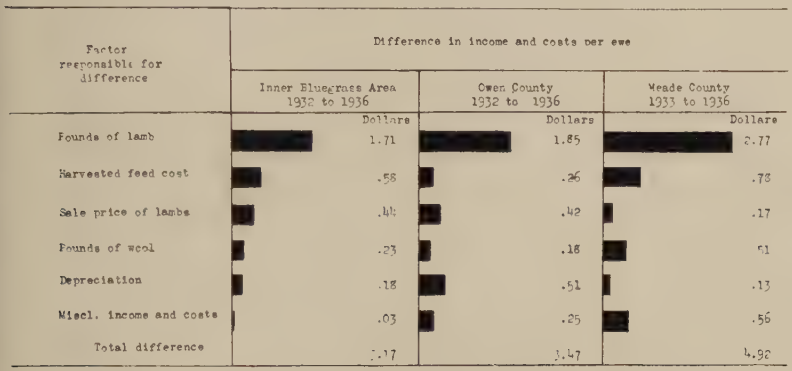

FIGURE 7. Factors responsible for differences in net return per ewe between the high-net-return flocks and the low-net-return flocks in the Inner Bluegrass Area and Owen County for 1932 to 1936, and Meade County for 1933 to 1936.

Many losses of lambs were due to unthriftiness of the ewes. This further emphasized the importance of keeping the ewes at the most favorable age and controlling parasites. To keep the flock thrifty the old or cull ewes, those with spoiled udders, those that did not produce sufficient milk for rapid growth of the lambs or ewes that otherwise proved to be poor mothers, were sold. Many of the more successful farmers marked the inferior ewes when they were first noticed. This lessened the chance of these ewes being overlooked at the time the cull ewes were sold.

The average weight per lamb, which was dependent upon age when sold and rapidity of gain or growth, was greater for the high-net-return flocks than for the low-net-return flocks. The lambs sold from the high-net-return flocks were younger since they were born about the same time as these from the low-net-return flocks and were sold sooner. The additional weight, therefore, was due to more rapid gains being made by the lambs of the high-net-return flocks.

The vigor or thriftiness and quality of the ewes, which influenced

Table 4. Cause of death in relation to the number of lambs raised.

	Number of flocks	Size of flock	Born dead or weak[1]	Starvation[2]	Chilled or frozen[3]	Miscellaneous[4]	Unknown	Lambs raised
		number	percent	percent	percent	percent	percent	percent
Inner Bluegrass Area:								
Percent of lambs raised, 1935								
Average or below	17	108	6	4	4	3	3	80
Above the average	17	110	4	2	1	1	2	90
Percent of lambs raised, 1936								
Average or below	16	91	8	3	5	2	4	78
Above the average	14	120	8	2	3	3[5]	1	83
Owen County:								
Percent of lambs raised, 1935								
Average or below	14	50	7	3	3	12[6]	2	73
Above the average	16	57	6	1	1	3	1	88
Percent of lambs raised, 1936								
Average or below	12	49	12	3	4	3	1	77
Above the average	13	48	8	..	1	2	1	88
Meade County:								
Percent of lambs raised, 1935								
Average or below	6	35	7	7	4	8	2	72
Above the average	10	38	5	2	1	3	1	88
Percent of lambs raised, 1936								
Average or below	6	36	4	4	12	5	1	74
Above the average	8	38	6	1	3	3	1	86

1 Lambs too large at birth, old ewes, cull ewes, poor condition of ewes, twins, triplets, premature birth and crowding of the ewes just prior to the lambing season. 2 Death of ewes, spoiled udders, lambs strayed, disowned, twins, triplets, poor condition of ewes, old ewes and cull ewes. 3 Cold weather and pneumonia. 4 Rickets, deformed, tetanus, accidentally killed, killed by dogs and worms. 5 Largely due to dogs. 6 Includes 2 flocks on which the farmers did not give the cause of death loss.

their production of milk, was an important factor influencing the rapidity of gain made by the lambs, because milk was the most important single food in the growth of the young lambs. In order to have the ewes in good condition at lambing time grain was fed prior to lambing by slightly over 50 percent of the cooperators in the Inner Bluegrass Area, about 80 percent in Meade County and about 85 percent in Owen County. About the same percentage of both the high-net-return and low-net-return flocks of these areas were fed grain prior to lambing. Grain feeding of the ewes prior to lambing varied from year to year. A larger percentage of the high-net-return flocks were fed grain prior to lambing when the fall and winter pastures were short, as during the fall of 1934 and the fall of 1935. The conditon of the ewe flock prior to lambing determined whether or not the ewes were fed grain for a time before lambing. This was a problem of flock management dependent upon the condition of the particular flock for the given year.

Creep feeding was a means of increasing the rapidity of gains made by lambs. About 60 percent of the lambs in this study for Meade County were creep fed; 30 to 35 percent of the lambs of the Inner Bluegrass flocks and 20 to 25 percent of the lambs in Owen County. For creep feeding little difference existed between the high and low net return flocks. The results of the high-net-return flocks indicated that it was more profitable to have small-grain pasture followed by good bluegrass and legume pasture than to creep feed the lambs. Creep feeding was a means of speeding up the growth of late lambs so as to reach the more favorable market.

Sale price. The sale price of lambs per hundred pounds for the high-net-return flocks was higher than for the low-net-return flocks in each of the three areas. Sale price accounted for 44 cents of the total differences in net returns per ewe for the Inner Bluegrass flocks; 42 cents for the Owen County flocks and 17 cents for the Meade County flocks, figure 7.

The average weight of lambs sold, by weeks, thruout the marketing season, was generally heavier for the high-net-return flocks than for the low-net-return flocks, figure 8. There was a tendency for the lambs of all flocks to be marketed at lighter weight as the marketing season advanced in each of the three areas.

Lambs lacking in weight were usually lacking in quality and

condition also and thereby had a lower dressing percentage than lambs of desirable market weight and condition. From this it seemed reasonable to assume that the lighter weight of the lambs as well as the increased number of lambs reaching the market dur-

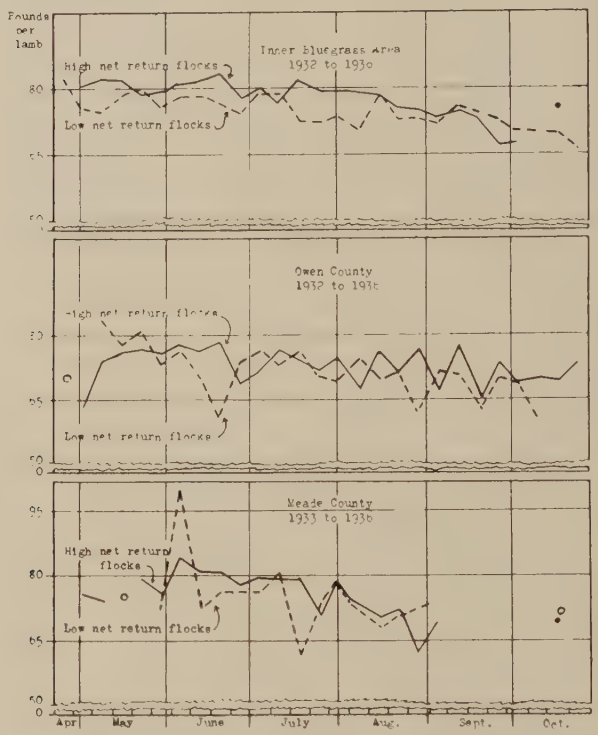

FIGURE 8. Average weight per lamb sold, by weeks, for the high-net-return flocks and the low-net-return flocks of the Inner Bluegrass Area and Owen County, 1932 to 1936, and Meade County, 1933 to 1936. These are averages from one-third of the flocks with the highest net returns, and one-third with the lowest net returns per ewe, each year. ● High net return flocks. ○ Low net return flocks.

ing the advanced marketing season caused the general decrease in price later in the season[14]. The difference in price was not due to seasonal price trend but to heavier weight and better quality of the lamb, since there was little difference in the distribution of sales by weeks between the high- and the low-net-return flocks.

The practices of castrating and docking should be expected to

14 Kentucky Extension Circular No. 303, Prices and Market Suggestions for Kentucky Stockmen.

influence price. Since most of the farmers (over 75 percent in Owen County and over 95 percent in the Inner Bluegrass Area and Meade County) castrated their ram lambs it appears that these farmers have found the practice profitable. There was little difference in the average percent of the lambs docked between the high and low net return flocks for the period of this study. A larger percentage of the lambs were docked in the Owen County flocks than in either the Inner Bluegrass or Meade County flocks. Since Owen County lambs are generally marketed later than those of either of the other two areas, it appears that the profitableness of the practice of docking was associated with the time of marketing. Many lambs marketed late in the season, that were not docked, became "taggy" and brought less than docked lambs.

Pounds of wool per ewe. A heavier wool clip accounted for 51 cents of the total difference in net returns per ewe between the high and low net return flocks in Meade County; 23 cents per ewe for the Inner Bluegrass flocks and 18 cents per ewe for the Owen County flocks, figure 7. Age of ewes and drenching were associated with the heavier wool production. As was true of lamb production, the wool production was influenced by vigor and thriftiness of the ewes, since the flocks with two-thirds or more of the ewes two to six years old produced more wool per ewe than those with less than two-thirds of the ewes two to six years old.

Cost of harvested feed. Cost of grain and hay accounted for 26 cents of the difference in net returns per ewe for the Owen County flocks; 58 cents for Inner Bluegrass flocks and 78 cents for the Meade County flocks (figure 7). This higher feed cost for the low-net-return flocks was the result of more grain and hay being used per ewe. The high-net-return flocks and the low-net-return flocks were on pasture about an equal number of days in the three areas. Since these groups were pastured about the same length of time, low carrying capacity of the pasture and poor condition of the ewes made it necessary for the farmers with low-net-return flocks to feed more grain and hay.

Depreciation cost. The depreciation per ewe was less for the high-net-return flocks than for the low-net-return flocks. Death of ewes accounted for practically all the difference in depreciation. During the period of the study death losses were: Inner Bluegrass

flocks, 10 percent and 12 percent; Owen County flocks, 6 percent and 11 percent, and Meade County flocks, 7 percent and 12 percent for the high and low net return flocks, respectively.

Miscellaneous income and costs. The miscellaneous income showed no significant difference except in Meade County where the high-net-return flocks were housed about a month longer. This increased the manure credit to these flocks. The man-labor cost was higher for the low-net-return flocks in Meade County than for high-net-return flocks because larger amounts of grain and hay were fed the low-net-return flocks. Pasture costs accounted for most of the difference in miscellaneous costs between the high and low net return flocks in Owen County.

THE PLACE OF THE SHEEP ENTERPRISE IN THE PROFITABLE ORGANIZATION OF THE FARM

The place of the sheep enterprise in the organization of the farm was determined in part by its income possibilities and in part by its demand for feed, labor, housing and other cost factors in relation to other enterprises on the farm. Sheep have a place in the organization of the farm as long as they enabled the farm to make at least as large or larger net earnings over a period of years as could have been made with any other enterprise that might have been chosen instead of sheep.

Crop and livestock combinations were different in different areas, as shown by comparing the crop acres and number of livestock on farms in this study, table 5. Farms in the Inner Bluegrass were slightly larger, had more acres of tillable crops per 100 acres of farm land and were more heavily stocked than the Owen County farms, and slightly smaller than the Meade County farms. The Owen County farms had the largest acreage of pasture per 100 acres of land while Meade County farms had the smallest. Little difference existed in the number of sheep per 100 acres of land, between the Inner Bluegrass and Owen County farms. The Inner Bluegrass farms and Owen County farms had three times as many sheep per 100 acres of land as the Meade County farms. More beef cows, feeder cattle and hogs and fewer dairy cattle were kept on the Inner Bluegrass and Meade County farms than on the Owen County farms.

The income from the sheep enterprise varied from area to area.

Table 5. Land utilization and number of livestock for farms in the Inner Bluegrass Area, Owen County and Meade County.[1]

	Inner Bluegrass Area				Owen County				Meade County		
	1934	1935	1936	3-year average	1934	1935	1936	3-year average	1935	1936	2-year average
	number	number	number	number	number	number	number	number	number	number	number
Number of farms	36	28	31	..	29	28	18		14	15	.
Acres operated per farm	274.7	251.7	290.5	273.1	143.1	141.9	141.9	142	290.4	281.9	286
Crop acres per 100 acres operated	35.9	34.5	26.1	32.1	21	25.1	18.9	22	37.1	24.7	30.8
Acres of pasture (permanent and rotation) per 100 acres operated	59.7	60.5	68.6	63.1	75.1	67.8	76.1	71.3	34.5	53.4	44.2
Other pasture acres	1.9	2.3	1.7	2.0	3.6	3.1	1.2	2.8	12.7	6.5	9.5
Livestock per 1000 acres											
Beef cows and heifers	25	29	25	26	5	2	..	3	23	24	24
Dairy cows and heifers	22	17	17	19	24	28	37	28	21	20	20
Feeder cattle	35	16	57	38	4	..	2	2	18	30	24
Ewes	359	372	308	345	336	350	370	349	126	118	122
Sows	14	10	10	12	6	4	5	5	9	10	10
Other hogs	60	55	45	53	10	16	25	16	24	36	30
Poultry	29	28	25	28	53	55	58	55	34	36	35

1 These data are from only those farms from which both detailed cost records of the sheep enterprise and farm business analysis records were obtained.

The Inner Bluegrass farms received over twice as much income per farm from sheep as the Owen County farms while the Meade County farms received slightly less than the Owen County farms, table 6. In relation to the total farm income the sheep enterprise was much more important for the Owen County farms, where it furnished about one-fifth of the farm income, than for either the Inner Bluegrass or Meade County farms. In the latter two farm groups, sheep furnished a little more than one-tenth of the total farm income.

The annual income from the Owen County flocks was equal to the investment. The Inner Bluegrass flocks and Meade County flocks produced $125 income for each $100 invested in sheep. In determining the place of the sheep enterprise in the farm organization, not only was total income in relation to investment important, but return above the cost, or net return, was also important.

Feed cost was shown in a preceding section of this bulletin to represent about 60 percent of the total cost in spring lamb and wool production. The sheep used, mainly, roughage and pasture with relatively small amounts of grain as compared with other kinds of livestock. Since this was true the sheep enterprise fitted into the systems of farming in the three areas, with varying degrees of importance so far as the whole farm was concerned. In the Inner Bluegrass Area and Owen County the utilization of roughage and pasture was one of the important problems confronting the farmers.

Earlier in this study the sheep enterprise was shown to make its greatest demands for labor during January, February and March, in the Inner Bluegrass Area and Owen County, and during these same months with a continued heavy demand thru April, in Meade County, figure 5. The labor requirements for the remainder of the year were relatively small in each of the three areas. This seasonal demand for man labor when the demand from other enterprises was the lightest made it possible for the farmer producing lambs and wool to obtain an income for his farm labor when it would not otherwise have been fully employed on income-producing enterprises.

Other factors, which vary in importance from one area to another, influenced the place of the sheep enterprise in the organization of the farm. The sheep enterprise provided an income to

Table 6. Livestock investment and net increase, and crop receipts for farms in the Inner Bluegrass Area, Owen County and Meade County.[1]

	Inner Bluegrass Area				Owen County				Meade County		
	1934	1935	1936	3-year average	1934	1935	1936	3-year average	1935	1936	2-year average
	dollars	dollars	dollars	dollars	dollars	dollars	dollars	dollars	dollars	dollars	dollars
Livestock investment	1727	1786	2820	2102	776	901	1078	873	1645	2150	1906
Horses	302	299	550	382	247	278	314	268	572	603	588
Cattle	683	663	1301	879	166	184	241	186	663	1073	875
Sheep	593	629	718	645	302	357	418	342	244	228	236
Hogs	98	147	198	145	14	22	39	22	94	159	127
Poultry	51	48	53	51	47	60	66	55	72	87	80
Income (net increase											
Livestock, total	1981	2508	2522	2312	684	725	925	738	1793	1496	1639
Horses	17	77	73	53	36	19	27	26	94	35	63
Cattle	723	859	996	852	169	188	175	173	710	375	537
Sheep	722	820	837	787	319	308	434	334	231	351	293
Hogs	426	647	494	514	34	65	94	59	573	591	582
Poultry	93	105	122	106	126	145	195	146	185	144	164
Crops, total	3507	3760	5715	4304	1006	1043	950	1018	617	411	510
Tobacco	2912	3090	5223	3721	946	1005	914	973	278	205	240
Wheat	279	183	213	229	13	5	3	7	118	171	146
Seeds	129	160	98	128	..	..	..	..	139	6	70
Other crops	187	327	181	226	47	33	33	38	82	29	54
Other sources	649	140	211	356	104	55	73	76	346	157	249
Total income	6137	6408	8448	6972	1794	1823	1948	1832	2756	2064	2398
Number of farms	36	28	31		29	28	18		14	15	

[1] The farms used in this table are only those from which both detailed cost data of the sheep enterprise and farm business records were obtained.

buildings and equipment which in all probability would not have been available if it were not for the sheep enterprise. This was particularly true in the Inner Bluegrass Area and Owen County where the sheep occupied the tobacco barns at a time of the year when they were not needed for tobacco. Sheep influenced farm earnings by controlling weeds in bluegrass seed, orchard grass seed and other seed and hay crops. This was an important factor in the Inner Bluegrass Area where bluegrass seed was an important cash crop on a large part of the farms. Many farmers expressed the belief that the tramping of the ground by sheep after the spring seeding of grass and clover in the small grain was helpful in obtaining a good stand.

What possibilities are there for sheep to make a satisfactory income when they make reasonably good use of feeds, labor, buildings and other resources? In deciding whether or not sheep will increase the farm earnings, it will be necessary to determine how well the nonmarketable feeds, the available man labor and tobacco barns or other buildings that would provide shelter for sheep are being utilized. If additional pasture, other nonmarketable feeds, labor and shelter are available on the farm, the sheep will increase the earnings of the farm by the amount that the receipts from the sheep exceed the market value of feeds, interest, depreciation and cash expense on sheep. As a partial answer to this problem assumed annual production with production requirements are presented in the form of three combinations for each of the three areas included in this study, tables 7, 8, and 9.

Production and production requirements for Inner Bluegrass flocks. For the Inner Bluegrass Area the average weight of lambs produced per mature head of sheep ranged from 41 pounds in one flock to 107 pounds in another, with an average of 82 pounds for all flocks. Wool production ranged from 4.5 pounds in one flock to 8.2 pounds per mature head in two flocks.

Corn was fed to approximately three-fourths of the flocks in the Inner Bluegrass Area. One flock was fed 58 pounds of shelled corn per mature head as a four-year average. About half of the flocks were fed barley or other small grain. One flock was fed 38 pounds of barley and 25 pounds of other small grain per mature head per year as an average of four years. Slightly less than half of

the flocks were fed bran. The average amount of concentrates fed per mature head was 17 pounds of shelled corn, 5 pounds of barley, 8 pounds of other small grain, 5 pounds of bran, 1 pound of linseed meal and 3 pounds of other mill feed.

Hay was fed to all flocks studied, the amounts varying from 33 pounds to 453 pounds per mature head and averaging 132 pounds per head. Two farmers fed silage and five fed stover. The average amount of roughage fed per mature head was 129 pounds of legume hay, 3 pounds of other hay, and 8 pounds of other roughage.

Pasture ranged from 208 days to 365 days, averaging 333 days per mature head. The variations in the length of grazing period in a particular year, between individual flocks, were largely the result of differences in the quality and quantity of pastures.

Man labor varied from 1.9 hours to 12.4 hours per mature head, averaging 3.8 hours for all flocks.

Miscellaneous costs, including such items as trucking, shearing, veterinary, medicine, salt and mineral, ranged from 18 to 90 cents per mature head. Shearing cost averaged 12 cents per mature head

Table 7. Sheep production requirements per mature head for Inner Bluegrass Region. Assumed annual production, 90 pounds of lambs and 7 pounds of wool.

Items	Amounts used annually[1]		
	Combination 1	Combination 2	Combination 3
Feeds:			
Corn, shelled, pounds	28	14	14
Oats, pounds	....	24	16
Bran and shorts, pounds	10	....	....
Linseed meal, pounds	3	....	3
Legume hay, pounds	150	200	150
Corn stover, pounds	100	....	100
Straw, pounds	50	50	50
Pasture, acres	.5	.5	.5
Labor:			
Man labor, hours	5	5	5
Horse work, hours	1	1	1
Miscellaneous:			
Depreciation, dollars	1.25	1.25	1.25
Shelter and equipment, dollars	.30	.30	.30
Shearing, dollars	.12½	.12½	.12½
Other costs, dollars[2]	.15	.15	.15

1 Only one of these feed combinations is used at a given time, the particular combination depending upon the kind of feeds available and the prices of different feeds. 2 Veterinary fees, medicine, salt, and twine.

for all flocks. Veterinary, medicine, salt and mineral averaged 10 cents per mature head for all flocks.

Production requirements and assumed production for Inner Bluegrass flocks. From the above data together with the recommendations of the Animal Industry Group of the Kentucky Agricultural Experiment Station production requirements and assumed production are suggested in table 7. It is assumed that the average flock will produce 90 pounds of lamb per mature head[15], and 7 pounds of wool.

The quantities of roughages are presented for a feed period of approximately three and one-half months, beginning December 15 and ending April 1. It is assumed that small-grain pasture will be grazed usually during the period the ewes are being fed harvested roughages. During mild winters small-grain pasture and bluegrass pasture may reduce the harvested roughage requirement of the flock.

Production and production requirements for Owen County flocks. In Owen County the average weight of lambs produced per mature head ranged from 42 pounds to 137 pounds and averaged 79 pounds for all flocks. Wool production ranged from 2.9 pounds for one flock to 9.6 pounds per mature head for another, averaging 5.2 pounds for all flocks.

Corn was fed to approximately 98 percent of the flocks in amounts ranging from 6 pounds to 197 pounds per mature head and averaging 44 pounds for all flocks. No barley was fed in Owen County whereas other small grain was fed to approximately one-fourth of the flocks. The small grain fed ranged from one pound to 77 pounds per mature head and averaged 9 pounds for all flocks. Bran fed to approximately twenty percent of the flocks varied from one pound per mature head for one flock to 23 pounds per head for another. Seven flocks were fed linseed oil meal and approximately 20 percent of them were fed mill feed. All except five of the flocks were fed legume hay. The amount of legume hay used per mature head ranged from 11 pounds for one flock to 400 pounds for another, and averaged 145 pounds per mature head for all flocks. Approximately one-fifth of all the flocks were fed non-legume hay and about half of them were fed other roughages such as straw and

15 Based on the number of head in the flock at breeding time.

corn stover. Pasture ranged from an average of 288 days per mature head for one flock to an average of 365 days for other flocks while all the flocks averaged 338 days annually.

Man labor varied from 1.6 hours to 18.6 hours per mature head, averaging 5.7 hours for all flocks.

Miscellaneous costs ranged from 6 cents per mature head for one flock to 69 cents per mature head for another, and averaged 29 cents for all flocks. In Owen County more than half of the farmers did their own shearing whereas the farmers in the Inner Bluegrass Area hired most of their shearing done. The costs to the flocks in Owen County for veterinary, medicine, salt and mineral averaged 8 cents per mature head for all flocks.

Production requirements and assumed production for Owen County flocks. For the Owen County flocks as for the Inner Bluegrass flocks the assumed production is 90 pounds of lamb and 7 pounds of wool for each mature head of sheep, table 8.

For the Owen County area the quantities of roughage are presented for a feed period of about four months beginning about the middle of December and ending about the middle of April. It is assumed that small-grain pasture, if possible, will be available during the late fall, early winter and early spring. During mild winters small-grain pasture and bluegrass pasture may reduce the amount of harvested roughages required by the sheep. Because winter feeding is earlier and spring feeding later, more grain and roughage are suggested for the Owen County sheep flocks than for the Inner Bluegrass flocks.

Production and production requirements for Meade County flocks. In Meade County the pounds of lambs produced per mature head ranged from 56 pounds in one flock to 108 pounds in another, and averaged 81 pounds for all flocks. Wool production ranged from 4 to 8 pounds per mature head, averaging 6 pounds for all flocks.

Corn was fed to all Meade County flocks in this study. The amount ranged from 11 pounds per mature head in one flock to 175 pounds in another, and averaged 73 pounds for all flocks. Barley was fed to one flock and other small grain to about 78 percent of the flocks. The amount of other small grain varied from 1 pound per mature head in one flock to 104 pounds in another. Less

than half the flocks were fed bran. Five flocks were fed linseed oil meal and two, other mill feed.

Table 8. Sheep production requirements per mature head, for Owen County. Assumed annual production, 90 pounds of lambs and 7 pounds of wool.

Items	Amounts used annually[1]		
	Combination 1	Combination 2	Combination 3
Feeds:			
Corn, shelled, pounds	40	30	30
Oats, pounds	....	25	15
Bran and shorts, pounds	5	....	5
Linseed meal, pounds	2	....	2
Legume hay, pounds	165	220	165
Corn stover, pounds	100	....	100
Straw, pounds	50	50	50
Pasture, acres	.6	.6	.6
Labor:			
Man labor, hours	7	7	7
Horse work, hours	1	1	1
Miscellaneous:			
Depreciation, dollars	1.25	1.25	1.25
Shelter and equipment, dollars	.30	.30	.30
Other costs, dollars[2]	.20	.20	.20

1 Only one of these combinations is used at a given time, the particular combination depending upon the kinds of feeds available and the prices of different feeds. 2 Veterinary fees, medicine, salt, and twine. If shearing is hired, this item should be increased to include the cost.

Legume hay was fed to all flocks in amounts varying from 79 pounds per mature head for one flock to 589 pounds per mature head for another, and averaged 322 pounds per mature head for all flocks. Other roughage was fed in addition to the legume hay by most of the farmers.

Pasture ranged from 222 days per mature head per year for one flock to 329 days for another, and averaged 266 days for all flocks. The pasture season in Meade County was shorter than in either the Inner Bluegrass Area or Owen County because of the lack of small-grain pasture and early spring and late fall bluegrass pasture.

Man labor varied from 1.9 hours to 11.8 hours per mature head and averaged 5.4 hours for all flocks.

Miscellaneous costs ranged from 23 cents for one flock to 63 cents for another, averaging 38 cents per mature head for all flocks. These costs were slightly higher than similar costs for either the In-

ner Bluegrass or Owen County flocks because a larger percentage of the Meade County flocks were drenched.

Production requirements and assumed production for Meade County flocks. For the Meade County flocks the same production per mature head was assumed, namely, 90 pounds of lamb and 7 pounds of wool, table 9.

The roughages provide for a feed period of four and one-half months beginning about December and ending about the middle of April. Since the roughage and concentrate feed periods were found to be longer in Meade County than in either of the other areas, larger amounts of the feeds have been suggested.

Table 9. Sheep production requirements per mature head, for Meade County. Assumed annual production, 90 pounds of lambs and 7 pounds of wool.

Items	Amounts used annually[1]		
	Combination 1	Combination 2	Combination 3
Feeds:			
Corn, shelled, pounds	85	50	50
Oats or other small grains, pounds	....	40	30
Bran and shorts, pounds	5	....	....
Linseed meal, pounds	4	....	4
Legume hay, pounds	300	350	300
Corn stover, pounds	120	....	120
Straw, pounds	60	60	60
Pasture, acres	.6	.6	.6
Labor:			
Man labor, hours	7	7	7
Horse work, hours	1	1	1
Miscellaneous:			
Depreciation, dollars	1.15	1.15	1.15
Shelter and equipment, dollars	.35	.35	.35
Other costs, dollars[2]	.25	.25	.25

1 Only one of these combinations is used at a given time, the particular combination depending upon the kind of feeds available and the prices of different feeds. 2 Veterinary fees, medicine, salt, and twine. If shearing is hired, this item should be increased to include the cost.

CONCLUSIONS

The sheep enterprise was considered as part of the entire farm organization even tho differences in flock-management practices resulted in wide differences in returns. Sheep seemed to be limited by the amount of pasture since the number increased as the acreage of pasture increased.

Sheep were a means of increasing farm income. They made pos-

sible a cash income from such nonmarketable feeds as pasture, stover and straw. They furnished remunerative employment for farm labor at times when there was little demand for it by other farm enterprises. They provided income from buildings such as tobacco barns which are not needed for tobacco at the time of the year when the sheep needed shelter. They influenced farm earnings favorably by controlling weeds in seed and hay crops. The fact that sheep consumed, mainly, roughages and pasture and relatively little grain gave them an advantage over other kinds of livestock in areas with a large percentage of the farm land in pasture. The farm, however, will be most profitable over a period of years if the proper balance between the various enterprises is maintained.

APPENDIX

Table 10. Average value in dollars per ewe, according to age, for Inner Bluegrass Area, Owen County and Meade County, 1934 to 1936.

Age, years	Lamb	1	2	3	4	5	6	7	8	9[1]	10[1]
Inner Bluegrass Area											
1934	4.67	7.21	6.63	6.04	5.11	3.89	2.62	1.70	1.31	....	....
1935	4.68	8.89	9.18	8.55	7.05	5.75	4.28	3.27	2.17	1.46	.75
1936	6.09	8.65	9.02	8.63	7.17	5.37	3.55	2.27	1.34	.72	.50
3-year average	5.14	8.24	8.27	7.73	6.44	5.00	3.48	2.41	1.60	1.09	.62
Owen County											
1934	5.35	8.38	8.78	8.11	6.84	4.65	3.24	2.42	1.67	1.05	.58
1935	4.75	9.16	9.29	8.59	7.54	6.46	5.45	4.10	2.83	....	....
1936	6.60	8.63	9.02	8.33	6.78	5.46	4.26	3.20	2.20	1.37	.75
3-year average	5.56	8.71	9.02	8.33	7.04	5.52	4.31	3.24	2.23	1.21	.66
Meade County											
1934	5.00	6.78	7.58	7.11	6.08	4.87	3.91	2.25	2.92	2.50	1.18
1935	4.59	7.79	8.57	7.65	6.81	5.04	3.85	2.67	1.00	....	....
1936	6.46	8.57	9.09	8.78	7.52	6.11	4.18	2.83	2.05	1.57	.83
3-year average	5.34	7.70	8.40	7.83	6.80	5.33	3.98	2.58	1.99	2.03	1.00

1 Number of values given inadequate for a significant sample.

Table 11. Costs and returns per ewe, per year, and average for Owen County and the Inner Bluegrass Area, 1932 to 1936, and Meade County, 1933 to 1936.

Items	Owen County						Inner Bluegrass Area						Meade County				
	1932	1933	1934	1935	1936	5-yr. average	1932	1933	1934	1935	1936	5-yr. average	1933	1934	1935	1936	4-yr. average
Number of flock years	20	103	32	30	25	210	42	42	40	34	30	188	13	16	16	14	59
Cost per ewe, dollars:																	
Pasture	2.70	2.71	1.96	2.14	1.44	2.35	2.48	2.40	1.78	2.17	1.96	2.16	1.21	.95	1.29	1.09	1.13
Harvested roughage	.70	.90	.84	1.06	1.33	.95	.65	.66	80	.87	1.38	.86	.95	1.75	2.00	1.71	1.65
Concentrates	.39	.40	.59	.80	.73	.53	.25	.31	.48	.42	1.06	.47	.66	.80	1.26	1.12	.97
Total feeds	3.79	4.01	3.39	4.00	3.50	3.83	3.38	3 37	3.06	3.46	4.40	3.49	2.82	3.50	4.55	3.92	3.75
Depreciation	.57	1.09	1.02	.95	.85	.98	.97	1.05	1.00	1.22	1.09	1.06	.78	1.12	1.23	1.44	1.15
Man labor	.47	.60	.47	.57	.66	.57	.35	.31	.36	.41	.55	.39	.58	.38	.69	.58	.55
Interest and taxes	.34	.32	.31	.41	.39	.35	.33	.28	.26	.39	.40	.33	.29	.34	.36	.40	.35
Net cost of ram	.30	.24	.18	.15	.32	.23	.43	.28	.22	.22	.26	.29	.22	.11	.38	.13	.21
Shelter and equipment	.28	.30	.23	.24	.24	.27	.27	.28	.22	.24	.28	.26	.21	.25	.26	.22	.24
Shearing	.01	.03	.05	.06	.03	.04	.11	.11	.14	.13	.13	.12	.02	.04	.03	.04	.03
Trucking	.20	.11	.08	.07	.07	.10	.10	.09	.07	.05	.06	.07	.02	.04	.20	.04	.03
Salt	.07	.05	.04	.04	.04	.05	.06	.05	.04	.07	.08	.06	.06	.06	.06	.05	.06
Veterinary and medicine	.01	.03	.04	.04	.02	.03	.06	.04	.03	.04	.03	.04	.05	.02	.04	.04	.03
Miscellaneous	.02	.02	.01	.01	.02	.01	.03	.06	.04	.03	.04	.04	.04	.03	.07	.11	.06
Total costs	6.06	6.80	5.82	6.54	6.14	6.46	6.09	5.92	5.44	6.26	7.32	6.15	5.09	5.89	7.87	6.97	6.46
Income per ewe, dollars:																	
Lambs	4.73	5.89	5.89	5.89	7.18	5.94	5.90	6.76	6.95	7.13	8.58	7.00	6.55	6.39	6.58	8.62	7.00
Wool	.60	1.57	1.54	1.33	1.73	1.46	.77	1.70	1.75	1.60	2.07	1.56	1.59	1.81	1.49	2.29	1.79
Manure	.17	.11	.11	.10	.13	.12	.10	.13	.07	.10	.15	.11	.22	.18	.22	.14	.19
Total returns	5.50	7.57	7.54	7.32	9.04	7.52	6.77	8.59	8.77	8.83	10.80	8.67	8.36	8.38	8.29	11.05	8.98
Net returns per ewe	—.56	.77	1.72	.78	2.90	1.06	.68	2.67	3.33	2.57	3.48	2.52	3.27	2.49	.42	4.08	2.52
Pasture and management returns per ewe	2.14	3.48	3.68	2.92	4.34	3.41	3.16	5.07	5.11	4.74	5.44	4.68	4.48	3.44	1.71	5.17	3.65

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Kentucky
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University of Kentucky

ORGANIZATION OF THE LOUISVILLE WHOLESALE FRUIT AND VEGETABLE MARKET

BULLETIN NO. 386

Lexington, Ky.
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Bulletin No. 386

ORGANIZATION OF THE LOUISVILLE WHOLESALE FRUIT AND VEGETABLE MARKET*

By H. B. PRICE, C. D. PHILLIPS and S. E. WRATHER†

City produce markets have been under considerable pressure in recent years to increase facilities for handling and to improve the organization for marketing fruits and vegetables. Increased consumption of these products has made it imperative to improve and expand facilities for handling them. Greater dispatch and mobility in transportation demand the development of those functions in marketing that facilitate commerce both in the state and to outside points. City markets that formerly functioned to supply the local population with fruits and vegetables are now often expected to take on the characteristics of a well-developed marketing system supplying a large territory. This is particularly true where there is local advantage in producing fruits and vegetables.

Some of the important characteristics of city produce markets that meet the requirements of present-day needs are: first, ample facilities, well located and equipped to handle the physical supply with dispatch and at a reasonable cost; second, a market organization that promotes exchange of commodities; and third, an adequate basis of information to facilitate exchange, including systems of price quotations, market news, grading and inspection of products, standardization of packs and packages and other functions designed to provide a basis of buying and selling.

This study was made to examine the Louisville market from the standpoint of present-day requirements for marketing fruits and vegetables. Information was secured thru personal interviews with growers who patronize the market, trucker-merchants hauling

* This bulletin reports a continuation of the study described in Bulletin No. 368 of the same title.

† Acknowledgement is made of the cooperation of S. W. Anderson, County Agent in Jefferson County, members of the Department of Horticulture, University of Kentucky, officers of the Jefferson County Farm Bureau, engineers in the Engineering Department of the City of Louisville, officials of the Gardeners' and Farmers' Market, wholesale dealers, inter-city truckers and fruit and vegetable growers too numerous to mention.

produce into and out of the market, established dealers who handle produce on the market, and records of railroads showing unloads of fruit and vegetables on the Louisville market. The study was started too late in 1935 to secure complete data, while in 1936 drouth conditions prevented data gathered that year from showing a true relationship between local conditions and shipments either into or out of the market. However, more normal conditions of marketing existed during 1937 and the results of inquiries made during that year are herewith presented.

IMPORTANCE OF LOUISVILLE AS A FRUIT AND VEGETABLE MARKET

Louisville is an important wholesale market for fruits and vegetables. It furnishes the main supply of these products not only for a population of about 400,000 living in the metropolitan area, but also for a much larger population living in Central Kentucky and Southern Indiana. The city is strategically located with respect to rivers, highways and railroads to receive fruits and vegetables from distant producing areas and to function as a distributing center for locally grown products thruout a large trade territory. It is the principal wholesale market outlet for most of Kentucky lying east of the Cumberland River and west of the mountain area in Eastern Kentucky, excluding a few counties near Cincinnati. Several counties in Southern Indiana are also easily served by it.

The city is especially important as a market place for locally-grown fruits and vegetables produced within a radius of forty miles. Ninety percent of the growers interviewed in 1937 operated farms within 30 miles of Louisville and less than 2 percent were located more than 40 miles. A few growers lived 200 or more miles from Louisville but they were exceptions. A large part of the production is within a radius of 20 miles. (See table 1.)

More particularly, most of the truck and small fruit-growers who patronize the market live in Jefferson county, in which Louisville is located. Of 293 growers who purchased permits to sell on the Gardeners' and Farmers' Market, for the 1937 season, 264 lived in Jefferson county, 10 in Bullitt county and two in Nelson county, Kentucky, while 17 lived in Indiana. (See table 2.)

Table 1. Distance from market of farms operated by growers interviewed during 1937 on the Gardeners' and Farmers' Market.

Distance from market (miles)	Number of growers	Percent of growers
Under 5	11	3.8
5-9	101	34.7
10-14	93	31.9
15-19	27	9.3
20-24	21	7.2
25-29	10	3.4
30-34	18	6.2
35-39	6	2.1
Above 40	4	1.4
Total	291	100.0

Table 2. Counties where producers live who purchased seasonal permits to sell on the Gardeners' and Farmers' Market during 1937.

County	No. of stalls	Percent of total
Jefferson	264	90.1
Bullitt	10	3.4
Nelson	2	.7
State of Indiana	17	5.8
Total	293	100.0

The volume of fruits and vegetables handled on the Louisville market has steadily increased in recent years. Railroad receipts in 1934 amounted to 4,174 carloads. This increased to 4,475 in 1935, and to 5,256 during the drouth year of 1936. During 1937, they decreased to 4,669 carloads. Data on receipts by motor truck are not complete, but what are available indicate that receipts by this means of transportation have increased to an even greater extent. In 1937 it was estimated that the equivalent of at least 2,500 carloads of fruits and vegetables, not including locally grown produce, were received by motor truck. It is also true that during the past few years, except in 1936 when production was drastically reduced by drouth, the supply of locally grown produce has increased. The total volume of fruits and vegetables, including local and distant sources, was therefore about 10,829 carloads in 1937, of which about 3,675 carloads were grown locally.

This increase in volume of fruits and vegetables appears to have been caused by the three following factors: first, increased con-

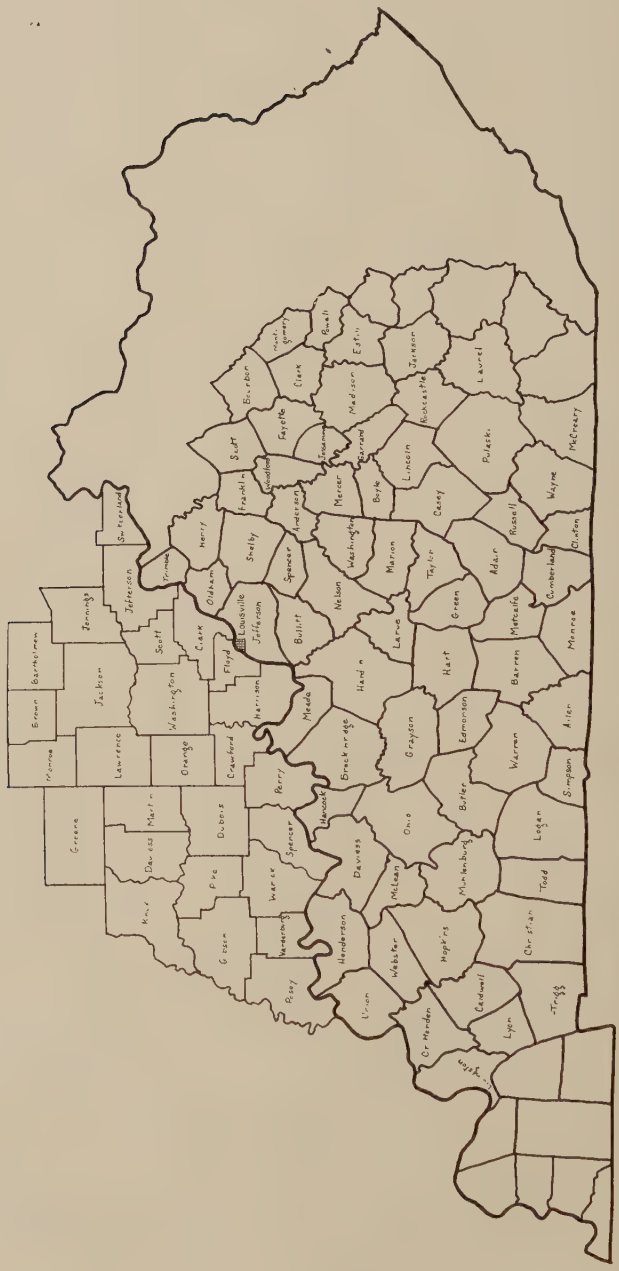

FIGURE 1. Kentucky and Indiana counties from which fruits and vegetables are marketed in Louisville.

sumption of fresh fruits and vegetables, especially at the time of year when the locally grown produce is not available; second, increased production of locally grown products; and third, improved transportation facilities. It is also probable that a portion of the increase is due to a gain in per capita consumption in the area in keeping with the growing per capita consumption for the country as a whole, and to an increase in population. The population of the Louisville metropolitan area increased nearly 30 percent in the decade, 1920 to 1930. Altho data for a later period are not available, estimates indicate that the number of people in the area is still increasing.

The delineation of market areas under the most favorable conditions of research is at best an approximation of borderlines of the areas, as the extent of a market area shifts with changes in the conditons of marketing. Judging from the movement of produce into and out of Louisville and also by the location and arrangement of highways and railroads, the area represented in figure 1, with production shown in table 3, is territory from which, under normal conditions, surplus fruits and vegetables produced are sent to Louisville. Production of fruits and vegetables grown in the area tributary to Louisville has shown considerable increase during recent years. Those commodities showing the greatest increase

Table 3. Production of fruits and vegetables in the Louisville market area.*

	1920	1930	1935
Fruits and vegetables harvested for sale, acres	26,121	50,499	73,769
Beans, acres	1,100	4,462	3,462
Cabbage, acres	674	1,364	1,896
Corn (sweet) acres	2,205	8,413	10,811
Tomatoes, acres	11,981	24,555	32,450
Watermelons, acres	3,603	3,574	10,259
Potatoes, acres	43,029	36,421	68,518
Sweetpotatoes, acres	8,217	7,299	14,927
Apple trees of bearing age	3,489,344	2,286,575	2,077,813
Cherry trees of bearing age	216,445	79,757	137,519
Peach trees of bearing age	1,545,570	1,523,112	1,448,018
Pear trees of bearing age	252,145	183,757	177,778
Plum and prune trees of bearing age	236,830	122,557	111,878
Grape vines of bearing age	474,042	475,630	661,374
Strawberries, acres	3,169	4,834	5,160

* Adapted from U. S. Census reports.

between 1920 and 1935 were cabbage, green corn, tomatoes, potatoes, sweetpotatoes, watermelons and strawberries. It is probable that further expansion will take place in the production of these products as there is an increasing demand for locally grown produce. During the period under consideration, production of tree fruits showed a substantial decline.

No information as to the growth of receipts and shipments of fruits and vegetables at Louisville by motor truck is available, except the observations and opinions of persons on the market. Their judgment is that the importance of this type of transportation is growing, and that trucking may be relatively more important to the future growth of Louisville than to many other markets, because of Louisville's location with respect to markets in the northern and southern producing states. Located as it is, on important north-south arterial highways and midway between important northern and southern markets, Louisville is a convenient point at which to exchange produce from the northern and southern areas. Thus the city becomes the terminus for fleets of trucks operating from the northern producing areas and from the southern producing areas. This situation provides opportunities that probably did not hitherto exist for the sale of locally grown fruits and vegetables, and lays the foundation for a large wholesale fruit and vegetable market which will not only serve the city of Louisville but will supply a much larger trade territory than is reached at the present time.

The forces making for a larger volume of business in fruits and vegetables will probably continue to operate as in the past. Population of the metropolitan area will probably increase as wholesaling, manufacturing and commerce in the city and surrounding trade area develop. Trucking of fruits and vegetables is gaining momentum and shipping perishables by rail continues to become more efficient. Production of locally grown fruits and vegetables will increase as there are better local marketing opportunities, as local demand increases, as faster and more mobile shipping develops and as physical facilities are enlarged and made more efficient for exchange of locally grown products.

ORGANIZATION OF THE LOUISVILLE FRUIT AND VEGETABLE MARKET

The Louisville fruit and vegetable market is organized similarly to other wholesale markets of like size and importance. A market place for farmers correctly known as the Gardeners' and Farmers' Market, but commonly referred to as the Haymarket, provides the main outlet for locally grown fruits and vegetables. Commission merchants and jobbers function chiefly to supply the local population and trade territory with fruits and vegetables shipped in from distant producing sections. These merchants also handle locally grown fruits and vegetables in season and, when there is a surplus of locally grown produce, find an outlet in other markets. A large quantity of locally grown fruits and vegetables shipped out of the area is handled by farmers' cooperative marketing associations and produce exchanges. Three produce exchanges ship a large proportion of the commercial potato crop grown in the nearby communities of St. Matthews, Worthington and Buechel, and a cooperative fruit-growers association ships a large part of the strawberries, peaches and tomatoes destined for other markets. Selling by this association is done under agreement with a local commission merchant. In 1937, the scope of its activities was enlarged to include the marketing of general truck crops. During recent years, with the increase of motor transportation, a new type of middleman has developed to meet the needs of inter-city truckers. Altho the function of these middlemen is primarly to locate sources of local supply, some also handle incoming produce on commission.

The present wholesale fruit and vegetable market is located in that part of the city generally devoted to wholesaling. It is known to have occupied the present location since 1892 when the Gardeners' and Farmers' Market was established. Since that time the volume of business has increased many fold. Changes and additions to facilities have been made from time to time to accommodate the expanding business, but in the absence of any plan for enlargment or reorganization, these changes were made only as a result of great congestion of traffic in the wholesale section or by the pressure of other circumstances.

During this development the wholesale fruit and vegetable

market became located away from railroad facilities. At present only one brokerage firm, the warehouses of three large chain stores, and a large wholesale receiver are located so as to have railroad facilities. All other wholesale dealers and jobbers, who handle fruits and vegetables, are located not less than three blocks from the railroad unloading tracks, and some incoming produce is un-

Main St.
Jefferson St.
Broadway
Fourth St.
Floyd St.
Preston St.
1. Floyd, Jackson and Water Street Train Tracks.
2. Ninth to Fourteenth St. Team Tracks and Chain Store Private Si
3. Thirteenth and Market Street Team Tracks.
4. East Louisville Team Tracks.
5. Gardners' and Farmers' Market and Wholesale District.
6. Chain Grocery Store Warehouses.
7. Cold Storage Plants.

FIGURE 2. Location of railroad unloading tracks in relation to the wholesale district in Louisville

loaded 15 city blocks from the wholesale section. (See figure 2.) This lack of proper coordination of facilities necessitates extra handling of much produce received by rail, and a haul over crowded city streets to get to the places of business of most wholesale dealers. Yet, until recent years, the major movement of foods into and out of the market was by railroad and, as pointed out earlier in this

report, several thousand carloads of fruits and vegetables are now shipped yearly by this mode of transportation.

Some further indication of the extent of handling and trucking is given in table 4. For example, during 1934-1937, 69.8 percent of the receipts of fruit and vegetables were unloaded at the team tracks located closest to the wholesale district commonly referred to as the Floyd Street, Jackson Street and Water Street district and located within three to six blocks of the wholesale district; 26.2 percent were unloaded at points from 9th to 14th Streets within a few blocks of Broadway, including the private sidings of two

Table 4. Location of carlot unloads.

	Yearly Average 1934-37		1937	
	Number of unloads	Percent	Number of unloads	Percent
Floyd, Jackson and Water Streets	3,242	69.8	3,500	75.0
14th Street, 9th and Broadway and Private Sidings	1,215	26.2	1,061	22.7
Market and 13th Streets	122	2.6	88	1.9
East Louisville	65	1.4	20	.4
	4,644	100.0	4,669	100.0

large chain-store companies; 2.6 percent were unloaded at the team tracks located in the vicinity of 13th and Market Streets; and 1.4 percent at the East Louisville team tracks located in the vicinity of the Baxter Avenue Station.

The handling of traffic has at all times been a problem with the growth of business and the substitution of motor trucks for horse-drawn vehicles. Streets have been widened and improved from time to time and arterial highways constructed to connect Louisville with other markets, but farmers, wholesale dealers, and inter-city truckers still find that streets leading to the market are congested during busy hours of the day and that delay is often experienced in getting thru traffic of the city on account of inadequate highways serving the market.

The increase of inter-city trucking has given rise to the need for facilities to expedite the exchange of fruits and vegetables handled by operators of trucks. To meet this situation the Gard-

eners' and Farmers' Market has designated a portion of its space as a market for truck merchants. Large open sheds have been erected to protect the loads from inclement weather, a covered platform for loading motor trucks and some equipment to assist in grading and packaging produce for out movement, have also been provided. Truck merchants wishing to sell their own produce can rent stalls on the market either by the day, month or year. Those selling fruits and vegetables in this manner must procure a license from the city for which a charge of $250 per year is made. The cost of the license was only $20 in 1936.

Besides these facilities, certain commission men who have developed a business to handle truck receipts on commission have warehouses or sheds where produce can be unloaded, graded and displayed for sale or sheds under which trucks can be placed and produce displayed for sale. Here there are usually very little equipment for handling and inadequate facilities for cooling fruits and vegetables. During the past year a former railroad freight building has been remodeled and modern facilities installed for handling and storing fruits and vegetables. At this writing the building is occupied by a wholesale dealer. The farmers' cooperative fruit and vegetable marketing association has also arranged to use a part of the building for handling and shipping fruits and vegetables.

Another type of middleman, which has recently developed, assists truck operators in locating sources of local supply for out shipments. These middlemen usually do not have warehouses or other facilities for handling fruits and vegetables but act merely as bargaining agents for truck operators. A common method of operation for such middlemen is to have offices situated near the market in Louisville, where supplies are located for the truck operator either by telephone or personal visits. At times produce displayed for sale on the Gardeners' and Farmers' Market is used as samples, while the product is actually purchased in the country by truck operators. On the other hand, some of these middlemen maintain an office outside the city near local producing areas. A significant result of this whole situation is to decentralize the fruit and vegetable market. Altho such arrangements may be of immediate advantage to truckers and growers, it can reasonably be questioned whether

the decentralizing effect on the market is desirable as a whole and in the long run.

Another significant result of congestion and the lack of proper coordination of physical facilities, has been the decentralization of the wholesale market and the scattering of marketing facilities, especially those for handling shipped-in produce. The physical facilities of the three largest chain-store grocery systems, all of which handle locally-grown fruits and vegetables as well as those which are shipped in, and two cold-storage plants, as shown in figure 2, are located in other sections of the city several blocks from the wholesale districts.

WHOLESALE DEALERS

There are about 25 wholesale dealers in fruits and vegetables in Louisville. Several of these firms do a wholesale receiving and brokerage business in addition to jobbing; the others have a strictly local jobbing trade. Except for one broker and one wholesale receiver, they are all located in the vicinity of the Gardeners' and Farmers' Market. (See figure 3.)

These dealers are important outlets for locally grown fruits and vegetables. Data obtained from them in this study show that in the aggregate they handle yearly the equivalent of 1,800 to 2,000 carloads of home-grown produce. Probably three-fourths of this amount is bought direct from growers at the dealer's place of business, and the remaining one-fourth from growers at the Gardeners' and Farmers' Market. Products bought by the first method, are generally obtained by prearrangement with growers as to the time of delivery, quantity delivered and basis of price. For the most part, growers marketing by this method are the larger producers as well as those producing the better quality products. Moreover, they market in this manner because they believe that the amount of expense and labor required is less and the outlet more certain than when selling on the farmers' market. It is interesting to note, however, that many of these farmers also sell fruits and vegetables on the Gardeners' and Farmers' Market in order to supply customers whose good will has previously been cultivated.

Locally grown fruits and vegetables bought by dealers are used

chiefly to supply local retail trade and nearby small consumers' markets; few are shipped to other wholesale markets because when delivered by growers the products are not properly packed and graded for sale in large lots. Most Louisville dealers are not equipped to sort, grade, pack and otherwise handle miscellaneous supplies that are to be sold in distant wholesale and jobbing centers.

THE GARDENERS' AND FARMERS' MARKET

Fruits and vegetables that are grown locally are sold primarily at the Gardeners' and Farmers' Market. They are also sold by growers direct to retail stores, to inter-city truckers, to hucksters and to wholesale dealers.

The Gardeners' and Farmers' Market is a public market of the open, wholesale type, located in the center of the wholesale district. (See figure 3.) The market place, consisting of parts of two city blocks with improvements, is provided by the Gardeners' and Farmers' Market Company, a stock corporation organized under the general corporation laws of Kentucky. The Market is constructed primarily to accommodate growers altho sale of fruits and vegetables is not restricted to growers or to persons selling locally grown produce. It is so organized as to promote sale at wholesale altho retail selling is permitted during the day up to 9 P. M. Actually sales made during the late morning, afternoon and early evening are predominantly retail, as most growers have left the market by 10 A. M. As soon as a grower has left the market, small retailers are permitted by the market company to occupy growers' places of business during the remainder of the day but not later than 7 o'clock except on Saturday when retailing ceases at 11 P. M. Retailers usually sell until 9 or 9:30, however, in violation of this rule.

The facilities provided for growers consist of a series of parallel platforms for the display of produce. Some of these platforms are nine feet wide and 12 inches above the driveway, while others, remodeled during 1936, are only three inches above the driveway, so that vehicles can be backed onto them. Sheds have recently been constructed over the platforms. On an adjacent lot recently purchased by the market company are sheds for the sale of fruits and vegetables brought to Louisville by truck merchants. On this lot

is also a loading shed, equipment for grading potatoes and onions, and an ice crusher which may be used by truck merchants for loading trucks, all of which facilitate the loading and grading of locally grown produce for shipment out of the market.

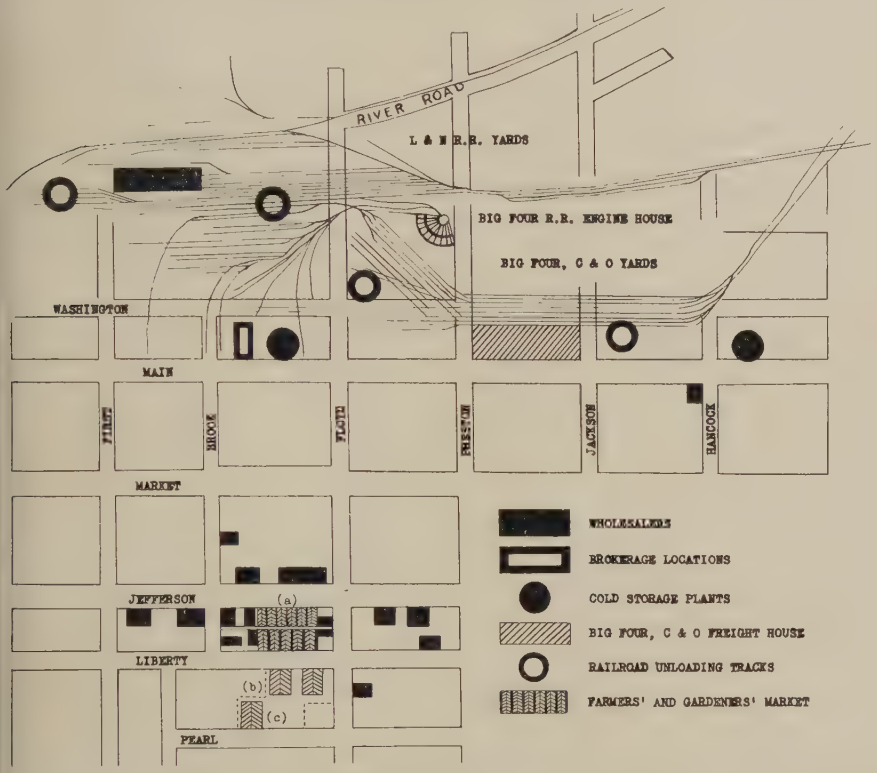

FIGURE 3. Wholesale fruit and vegetable district of Louisville. On the Farmers' and Gardeners' Market (a) is the section used by local farmers, (b) the part used by truck merchants, and (c) the loading shed.

Farmers patronizing the market are of two general types, (1) those patronizing the market regularly, and (2) those marketing produce for a short time during the year; the former generally purchase permits by the season, the price varying with the desirability of the location; the latter usually obtain permits by the day and encounter the risk of having to accept less desirable or poorly located stalls. Frequently two growers cooperate in purchasing per-

mits and thus obtain a more desirable location. Of the 204 stalls rented by the season in 1937, 99 were partnership stalls. The first group of growers generally includes producers of an assortment of fruits and vegetables who tend to locate near the market. The occasional farmers, for the most part, come from greater distances and grow one product for market, as green corn, tomatoes or melons.

Buyers in the Gardeners' and Farmers' Market are truck merchants, retail grocers, hucksters, wholesalers, and retail chain stores, in the order of importance. This conclusion is based on estimates of 77 producers, interviewed on their farms in 1937, 70 of whom designated the truck merchant as their best customer. About 45 percent of the products sold on the Gardener's and Farmers' Market in 1937 were purchased by truck merchants. This was equivalent to about 1,000 carloads according to calculations of the authors. The total sales on the Gardeners' and Farmers' Market during the 1937 marketing season (April 1, 1937, to April 1, 1938) amounted to 23,000 farm truck loads or the equivalent of about 2,300 carloads.

The Gardeners' and Farmers' Market has provided a valuable service for local growers of fruits and vegetables for more than forty years by furnishing a market place. The continued, widespread patronage of Kentucky and Indiana growers is evidence of its importance. However indispensable the market may be, many growers are still of the opinion that the organization and operation of the market are not adequately adapted to present marketing requirements. The problems that concern them most are: (1) the long, unregulated selling hours; (2) the intermingling of retail and wholesale sellers; (3) the competition of shipped-in produce with home-grown products; (4) an absence of supervision of grades and packages; (5) the inadequacy of market information; and (6) the congestion of traffic in and near the market place.

The problem that gives growers the greatest concern is the large amount of time that is required to sell produce. Farmers who sold 275 loads of produce during 1937 can be divided into two groups: first, those who arrive at the market between 4:30 and 10 P. M. in order to take advantage of the evening market when most of the truck merchants purchase their supplies. If the load is not disposed of during the evening, these producers remain on the market all

night in order to complete the sale of produce on the morning market. Thus, in order to take advantage of both the evening and morning markets, many producers spend from 11 to more than 15 hours, as shown in table 5, on the market. Producers in the second group arrive between 1 and 3 A. M., and use only the morning market. These farmers usually spend less than seven hours on the market. The largest percentage of farmers spending less than seven hours on the market, were of this group. Because of these long hours required to sell produce not only the cost of marketing is high, but growers are confronted with the dilemma of either spending unreasonably long days supervising the production and selling of their crops or of giving inadequate directions to the growing or to the selling of their produce.

Table 5. Time required to sell a load of produce on the Gardeners' and Farmers' Market during the 1937 season.

Time	Number of growers	Percent of growers
Under 5 hours	72	24.7
5- 6.9	57	19.6
7- 8.9	23	7.9
9-10.9	5	1.7
11-12.9	32	11.0
13-14.9	56	19.3
15 hours and over	46	15.8
	291	100.0

An important reason for the delay in selling fruits and vegetables is the character of the buying. Grocers, hucksters, wholesale dealers and others buying for local consumption ordinarily obtain their daily requirements of fruits and vegetables during the early morning hours before retail establishments open for business, whereas those agencies buying for out-of-city shipments must buy their supplies at a much earlier hour. During the past two seasons, however, many local buyers have taken advantage of the evening markets established for out-of-town buyers. This practice reduces the congestion of the morning market but growers who wish to profit from the evening market and also retain their established trade in the morning market must of necessity reach the market much earlier than heretofore and often spend the night or as long as is required to dispose of their produce.

Another reason for slow sales is the crowded condition which exists at times. Immediately this situation is, in part, due to inadequate approaches and narrow driveways and platforms for the display of produce and exchange of commodities offered for sale. In part it is also due to retailers prematurely crowding into the market place with their push carts, the failure of speculators to move out of the market place at the hour designated by rules, or hucksters using a part of the market to sort produce and pack their vehicles for the daily trade. Parking of cars by retail buyers in or near the driveways is frequently an obstacle to free movement of traffic. The situation has been created by the increase in volume of locally grown fruits and vegetables, by the substitution of trucks for horse-drawn vehicles in farm marketing, and by the growth of truck merchants as an important outlet for sale of locally grown fruits and vegetables. The rebuilding of half of the old market place with new, wider and lower platforms and with wider driveways has caused a marked improvement. The development of an adjacent area as a fruit and vegetable market for itinerant truck merchants, with covered stalls and a covered loading platform, has also tended to relieve the congestion of the market place. The rerouting of street cars, and the speeding up of traffic on Jefferson street, has to some extent at least, relieved congestion on the streets approaching the market.

In spite of the fact that most growers desire short, definite marketing hours, very few agreed on what the hours should be. One group preferred a short morning market, while another group suggested both an evening and a morning market. Those wanting only a morning market were, for the most part, producers living close to the market, and producing a wide variety of commodities destined chiefly for local consumption. On the other hand the producers who wanted both evening and morning markets generally lived farther from the market; their production is more highly specialized; and they are more dependent on truck merchants to buy a part of their produce.

The principal out-of-pocket expenses for selling on the Market are charges for stalls, hire of helpers and a clean-up charge. The cost of permits varies with the location of the stall and it is also

dependent on whether the permit is for the entire season or on a daily basis. In 1937, the cost of annual permits for 48 growers ranged from $10 to $115 and averaged $50.03. Annual permits on the market vary from $50 to $110, but some producers purchased more than one permit or shared the permit with other producers. These growers averaged 88 trips to market per year. Thus the average cost of permits per trip was 57 cents. The daily clean-up charge was 25 cents and the cost of helpers averaged 73 cents per trip. Thus total cost per trip was $1.55. The total cost per trip varied among these 48 growers from 75c to $3.25.

The out-of-pocket expenses of 101 growers who obtained permits on a daily basis were: permit 50c to $1.00, average 66 cents per trip; hired helpers, 25c to $1.50, average 70 cents per trip; total cost averaged $1.36. No clean-up charge, as such, was collected from this class of patrons. The total cost of this group was slightly lower than the cost of those obtaining permits on an annual basis.

As representative loads of fruits and vegetables sold for about $35, the out-of-pocket selling expenses amounted to about 4 percent of sales value. Total cost of marketing locally grown products would include also expenses of operating a truck, meals, labor of the grower or his representative, and occasionally bridge tolls. Data for these costs are not available.

Many producers sell fruits and vegetables directly to wholesale dealers or to chain-store organizations. Products disposed of in this manner are generally sold by prearrangement with dealers as to the time of delivery, quantity delivered, method of grading and packaging and basis of price. For the most part, growers marketing by this method are the larger producers as well as those handling the better quality products. They market their products in this manner because of economy and convenience, not only do they avoid serious delay in selling and delivering produce but there is also greater certainty of a market. It is interesting to note, however, that of the 77 producers interviewed during 1937, 28 sold part or all of their produce to chain stores, wholesalers, or at the farm. Only 4 of this group sold exclusively to wholesalers, and 2 sold only to chain stores, the other 22 sold a part of their produce at the Gardeners' and Farmers' Market in order to supply customers

whose good will had previously been obtained. The other 49 sold exclusively on the Gardeners' and Farmers' Market.

STANDARDIZATION OF PRODUCTS

Price quotations and market news service for locally grown fruits and vegetables are undeveloped, except as prices are quoted by a large wholesale merchant and these quotations represent prices at which jobbers are selling produce and not the prices being received by growers. Furthermore, no organized effort has been made to adopt uniform containers or to standardize grading. Products are marketed for the most part in a great assortment of containers; packs are not uniform as between growers and quality varies widely. Much confusion exists as to prices and wide variations in price for products of similar quality and pack often prevails on the market, indicating the weak bargaining and selling. Containers, packaging and quality of products and market news take on new significance, as opportunity for export of locally grown products appears. The present basis of sale served for products destined for local consumption when buyers could thoroly examine purchases, but it is wholly inadequate for a satisfactory and flourishing trade between cities.

The need for standardization of containers, packaging and grading was shown by a study of some of the products marketed during the 1937 season. The products chosen for study were those which entered, to the largest extent, the export trade: kale, spinach, strawberries, cabbage, tomatoes, beans and grapes.

Containers. For example, there is no organized effort among growers of locally grown fruits and vegetables to use standard containers. The prevailing custom calls for half-bushel, round-bottom baskets for tomatoes, altho flat-bottom, half-bushel baskets, large, flat, half-bushel baskets and other kinds of bushel baskets are also used. Produce of all kinds is generally sold with the understanding that the container in which the produce was sold will be returned to the producer, or one of the same kind. This practice frequently results in the use of many types of containers by individual producers. The more substantial containers, often new ones, are used for the heavier commodities such as cabbage, apples, peaches, and tomatoes. When baskets become discolored and broken, they are

used for greens. The general attitude toward containers is well expressed by the statement often heard in conversation with growers and dealers that any old basket is good enough for greens and certain other kinds of products. This policy may have been acceptable when products were grown for local consumption but it becomes increasingly uneconomical as production is planned for distant markets. Many instances were observed of the difficulties of selling products that were packed in miscellaneous, unstandardized packages. One of the most outstanding illustrations of the result of the use of an attractive package was observed during the strawberry season of 1937. Berries were generally packed in plain 24-quart crates but certain producers used an attractive display crate. Without exception fruit packed in the display crates sold more easily and commanded prices equal to or higher than the prices for similar quality berries packed in less attractive containers.

Grading. Likewise, there are no generally accepted standards of quality by which products can be graded and no system of inspection for the market. Each producer sorts and classifies his products by his own standards. Consequently, there was much evidence of various methods of sorting and grading products by growers and great variations in quality of products in individual packages. In fact the variations in quality were so great that great difficulty was experienced by the authors to grade certain selected products, since there was frequently a considerable quantity of products of low quality in packages that were intended by growers to be in a grade of high quality. That such practices were not always intended to be deceptive is shown by the fact that produce of good quality was often found in packs predominantly of low quality.

Packing. There was also great variation in the packing of fruits and vegetables as one would expect where there is great confusion in kinds of containers and grading. For example, there was confusion in the methods of arranging various products in packages. In the case of tomatoes a jumble pack was most common altho some growers arranged the top layer in various ways in an endeavor to have an attractive package. Strawberries were also packed in various ways. Most berries were jumble packed, altho some had the upper layer of cups plated, and in a few cases all cups in the

crate were plated. In every instance the crates that were plated thruout sold for 25 cents above berries of equal quality in jumble packs. The crates with only the upper layer of cups plated seldom sold for a higher price than the crates with a jumbled pack, but in almost every instance they sold more readily. Spinach and kale were also occasionally plated and in such instances the packages were generally carefully packed from bottom to top. More generally these products were just dumped into the container by the handful. The first method saved the delicate spinach from being bruised and the stems from being broken. In every instance when the package was properly packed and attractively plated the package sold first and at a higher price. Often at the close of the market the spinach which remained unsold was poorly packed and graded and growers were forced to sell it at reduced prices.

The second measure used to test the uniformity of packs was the weight of contents of various packages. Packages of various kinds of produce were weighed. These were selected at random on the Gardeners' and Farmers' Market, from deliveries made by producers to wholesale houses, and, in the case of strawberries, from samples taken at local loading stations in the county. The weight of contents of packages are shown in tables 6, 7, 8 and 9. It is interesting to note that in many instances the weight varied more than 100 percent. This was true of spinach which varied from 13 pounds net to 28 pounds and averaged 18 pounds. The weight of the various packages of kale also varied more than 100 percent or from 12 to 25 pounds net, with an average of 18¾ pounds. The weights of half-bushel packages of tomatoes averaged 28 pounds but varied from 24 to 34 pounds, net. The weight of a bushel of cabbage varied from 33 to 50 pounds net and averaged 42 pounds. The weight of the cabbage which graded good, however, averaged 44 pounds while that which graded poor averaged only 40 pounds.

The variation in weight resulted primarily from differences in packing containers. Some producers filled containers only to the top while others heaped the container. In the case of greens, weight not only depended upon the amount in a basket but also on the amount of water sprinkled on the contents. Also kale with large, heavy stems weighed more than the younger, more leafy kind. In

the case of cabbage, the variation was due not only to the manner of packing in the basket but also to the solidness of the heads and the method of trimming them. Altho many producers stated that small, overripe strawberries weighed more than the larger berries, there was no indication that this was correct. Weight appeared to depend chiefly on the fullness of the cups. Crates which had been plated usually weighed slightly more than those which had been packed by the jumble method.

Table 6. Net weight and grade of bushel packages of spinach examined in Louisville in 1937.

Net weight lbs.	Number of packages	Number of each grade		
		Good	Medium	Poor
13	3	1	2	0
14	7	4	1	2
15	11	3	8	0
16	14	8	5	1
17	14	8	5	1
18	10	6	4	0
19	27	18	8	1
20	11	8	3	0
21	10	6	2	2
22	2	2	0	0
23	4	0	3	1
24	1	0	0	1
25	1	0	1	0
26	1	0	0	1
27	0	0	0	0
28	1	0	0	1
Total	117	64	42	11

Packages of greens frequently were heavy because too much had been crowded into them. This often resulted in bruised leaves, broken stems, and an unsatisfactory looking package. More damage had been done to the contents, with a resulting lowering of price, than if less product had been put in the package. In fact, certain buyers demanded that only 12 to 14 pounds of spinach be packed in a bushel basket, in order to prevent such waste. With the trend in many cities to set up rules and regulations covering the weight of packages, it can readily be seen that a buyer from an outside market would find it difficult to get a load of produce packed according to his need. Under these conditions, buyers often completely repacked their purchases before selling on other markets.

Table 7. Net weight and grade of bushel packages of kale examined in Louisville in 1937.

Net weight lbs.	Number of packages	Number of each grade		
		Good	Medium	Poor
12	3	1	1	2
13	8	4	2	2
14	5	3	2	0
15	15	3	9	3
16	11	2	5	4
17	20	4	11	5
18	17	3	11	3
19	25	8	15	2
20	20	15	3	2
21	28	7	19	2
22	7	3	2	2
23	3	0	3	0
24	7	0	7	0
25	5	1	1	3
26	0	0	0	0
27	1	0	1	0
28	0	0	0	0
29	1	0	1	0
30	1	0	1	0
Total	177	54	93	30

Table 8. Net weight and grade of bushel packages of cabbage examined in Louisville in 1937.

Net weight lbs.	Number of packages	Number of each grade		
		Good	Medium	Poor
33	1	0	0	1
34	1	0	0	1
35	2	0	0	2
36	5	0	3	2
37	11	0	1	10
38	13	0	1	12
39	10	0	3	7
40	13	1	4	8
41	11	0	3	8
42	16	5	4	7
43	14	4	5	5
44	9	1	4	4
45	15	2	9	4
46	12	5	5	2
47	8	1	5	2
48	8	1	4	3
49	6	0	3	3
50	4	0	3	1
Total	159	20	57	82

Other out-of-town buyers found it desirable to order produce packed in a specified manner, while still others, after a trip or two, went elsewhere for supplies. This condition which exists on the local market certainly makes it more difficult to conduct trade with dealers from other cities. Producers interviewed during the summer stated that some public or market agency should promulgate rules and regulations governing the packaging and grading of produce. In fact, 46 of the 77 interviewed stated that the market could not assume its proper place in inter-city trade until proper grading and packaging was required of all producers. Opinion of growers as to what agency should enforce the regulations was about equally divided between the Market Company, the City, the State and the Federal Government.

Table No. 9. Net weight and grade of half-bushel packages of tomatoes examined in Louisville in 1937.

Net weight lbs.	Number of packages	Number of each grade		
		Good	Medium	Poor
24	1	0	1	0
25	5	3	2	0
26	11	2	6	3
27	37	7	24	6
28	54	21	26	7
29	54	26	22	6
30	36	16	17	3
31	18	8	9	1
32	2	2	0	0
33	2	2	0	0
34	3	2	1	0
Total	223	89	108	26

Prices. Under the existing uncertainty of grade, quality and package, and without market quotations, there is a great instability of prices of locally grown fruits and vegetables. As a consequence, a product of the same quality and package often sold at different prices in different parts of the market, or a product of inferior quality sometimes sold at a better price in one part of the market than a superior product of the same kind sold for in another part, thus indicating the disadvantage to growers of marketing without adequate standardization of products and a market news service.

Inadequate information on receipts of products also added

much to the confusion. This frequently resulted in oversupply and unsatisfactory prices following market days of satisfactory prices. Observance of accepted grading and packing standards and collection of data on receipts and shipments would provide the basis for a market news service and for more orderly marketing. Another need for such service is found in the growing competition of fruits and vegetables from other producing areas. The progress that is being made generally in grading and packaging those products, places local growers of poorly graded and poorly packed products at an increasingly great disadvantage. A large number of growers express their preference for prohibiting such shipped-in products from being offered for sale locally when similar home-grown products are being offered for sale, thus reducing, if not wholly eliminating competition from this source. Owing to the legal and economic difficulties of establishing such a policy for any particular city, such as Louisville, and with the probability of its adoption very remote, growers must rely on their own efforts to meet the competition by offering products of equal or better quality, container and pack than their competitors.

INTERCITY TRUCKING

No information as to the growth of shipments of fruits and vegetables into or out of Louisville by motor truck is available, except thru the observation and opinions of persons on the market. Their judgment is that the importance of this method of transportation is increasing. About 6,000 truck loads, or the equivalent of 2,500 carloads, of fruits and vegetables were brought into Louisville from distant producing areas by motor truck during the 12-month period, May 1, 1937, to April 30, 1938. In the same period 3,700 carloads of locally grown produce were trucked in and 4,627 carloads were brought to Louisville by railroads. Total monthly supply of fruits and vegetables and the portion furnished by local producers, shipped into the market by railroads and brought in by motor trucks are shown in figure 4. Fruits and vegetables were brought into the city by motor truck every month of the year, altho the bulk of the shipments were received during the months of July, August, September and October. The seasonality of the truck re-

ceipts corresponds to that of home grown products and is somewhat the reverse of receipts by rail. Truck receipts are heaviest in summer because weather is more favorable for trucking and sources of supply of fruits and vegetables are nearer Louisville than in the winter.

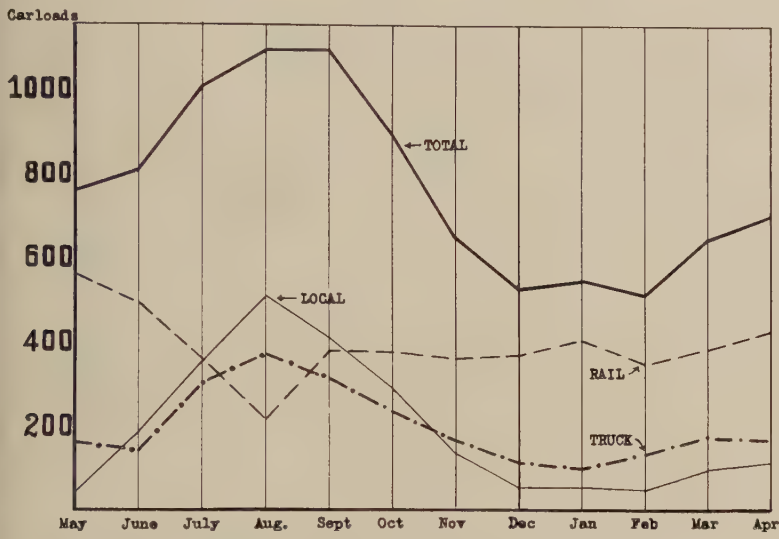

FIGURE 4. Total monthly supply of fruits and vegetables from locally grown produce, rail receipts and truck receipts, for the period, May 1, 1937, to April 30, 1938.

Thirty-eight truck operators were licensed by the City in 1935, to sell products trucked in from other producing areas. The number increased to 122 in 1936. As a result of changes in ordinances of the City regarding licenses and the fact that the ordinances were not consistently enforced, the number of licenses issued decreased materially in 1937. However, records kept by the authors show that 270 operators of trucks did a trucking business in fruits and vegetables during the period, July 1 to September 4, 1937. Of these truckers, 217 brought fruits and vegetables to Louisville, while 48 hauled such produce away. Only five of these truckers brought produce into and took produce out of the market. Some operators brought only one load into the market during the period while others brought as many as 82 loads. Also many of them had more

than one truck, so that considerably more trucks were represented than individual operators. Forty truckers had headquarters in Louisville and operated from there. The remainder claimed some other city as their principal place of business.

In the absence of any central place for the exchange of commodities received by motor truck, truck merchants do business in different sections of the market, altho they are most commonly found at a wholesale dealer's place of business or at the Gardeners' and Farmers' Market where a special part is reserved as a place for them to do business. In 1937, the City imposed an annual license of $250 on this type of dealer, providing they sold their own products; consequently, many itinerant truck merchants consigned their loads to wholesalers and jobbers, while others rented a storeroom and purchased an "established dealers' "license which was only $100. But as the city was lax in enforcement of the ordinance during most of the year, many truckers operated without license.

In buying produce for shipment to other markets, truck merchants purchase home grown products from farmers at the farm, from growers at the Gardeners' and Farmers' Market, from wholesale dealers, and from local brokers who establish contact with growers.

Truck operators in the fruit and vegetable trade, in common with other classes of truck operators, have an important problem in obtaining an outgoing load as more of them are bringing products to sell than are coming to buy. Being engaged in the fruit and vegetable business they prefer to haul only fruits and vegetables. In fact, preferences for hauling only these products is so strong that they often travel without cargo if fruits and vegetables cannot be secured. Occasionally they can arrange for outbound cargo. For example, a few contracted with a local brewery to haul beer to other cities, but generally trucks travel empty one way. During the period, July 1 to September 1, 1937, 217 different operators brought 1,081 truck loads of produce into Louisville while 53 operators hauled 199 loads away. Only 5 of these truckers brought loads into and took loads away from the market. In the previous season the 70 operators interviewed brought 127 loads into the market, and purchased for shipment only 65 loads during the period.

April 27 to July 10, 1936. The difference in the ratio for the two periods studied can be explained to a large extent by a heavy out-movement of greens and strawberries to northern markets in 1936. (See figure 5.)

Seasonality of production of fruits and vegetables is a principal reason for the difference between receipts and shipments. Altho at certain periods there are not enough locally grown fruits and vegetables to supply the Louisville market and altho during these

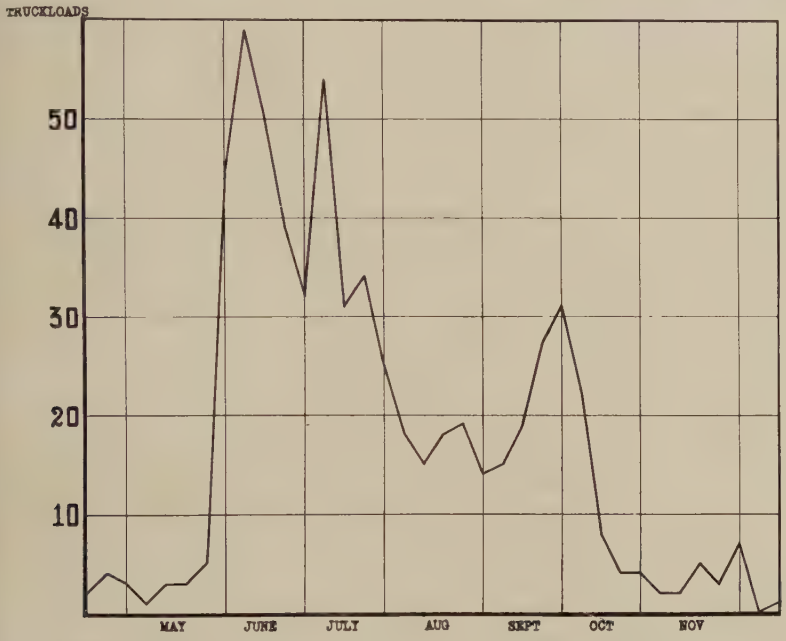

FIGURE 5. Monthly truck shipments of fruits and vegetables from Louisville to other markets during the 1937 season.

periods shipments are received from regions of peak production in order to supplement the local supply, nevertheless, whenever local produce is available for shipping it is rarely sent to those regions shipping to Louisville; thus there is seldom direct exchange. Other reasons for differences between in-shipments and out-shipments appear to be (1) poor facilities for the exchange of locally grown

products and (2) non-uniformity of pack and grade, which make it difficult to secure round lots of home-grown products suitable for wholesale trade in other markets. Altho the relative importance of these reasons is not known, it is reasonable to believe that growers and marketing agencies have not fully developed the opportunities offered by these itinerant truck dealers.

Another type of itinerant truck merchant does a jobbing business within convenient trucking distance of Louisville, buys his supplies of fruits and vegetables in Louisville, and sells them in small markets along the main highways. There are about 25 such operators. They commonly visit customers daily, filling orders of the previous day, taking new orders and returning to Louisville to obtain fresh supplies for the following day. These truckers do not present any problem for the central market not already mentioned for other truck operators, but they do offer an increasingly important outlet for the distribution of products grown in the vicinity of Louisville as well as those products shipped into the market.

SEASONAL USE OF MARKET FACILITIES

Some locally grown produce is marketed every month of the year. (See figure 4.) However, only during a comparatively short period of the year are the facilities of the Gardeners' and Farmers' Market utilized near capacity, and then only on certain days of the week. The market has 261 covered stalls between Jefferson and Liberty streets, and some uncovered stalls on the south side of Liberty street that can be used for farmers' stalls. The largest number of producers counted on the market on any day during the past season, was on September 25 when 260 farm trucks were parked on the Market between 5 and 6 o'clock in the morning.

On only 12 days during the summer of 1937 were more than 200 farm trucks on the Market when the count was made, between 5 and 6 A. M., while on only 77 days were there more than 100 farm trucks. Under these circumstances, if all covered stalls had been used only for the sale of produce by growers, the space reserved for growers would never have been completely occupied in 1937. During the four weeks in August there were more than 1,000 farm trucks per week, or 23.8 percent of the yearly total. (See figure 6.)

Consequently, the facilities needed to handle the peak load were required for only one month of the year. In fact, nearly 60 percent of the yearly total were reported in the three months of July, August and September. Saturday was the most important market day. Tuesday was second and Monday was least important. Expressed as percentage of all trucks, 23.6 percent were accounted for on Saturday, 20 percent on Tuesday and 11.7 percent on Monday.

It was interesting to note that the number of producers who bought daily permits (see figure 6) increased rapidly to a peak in

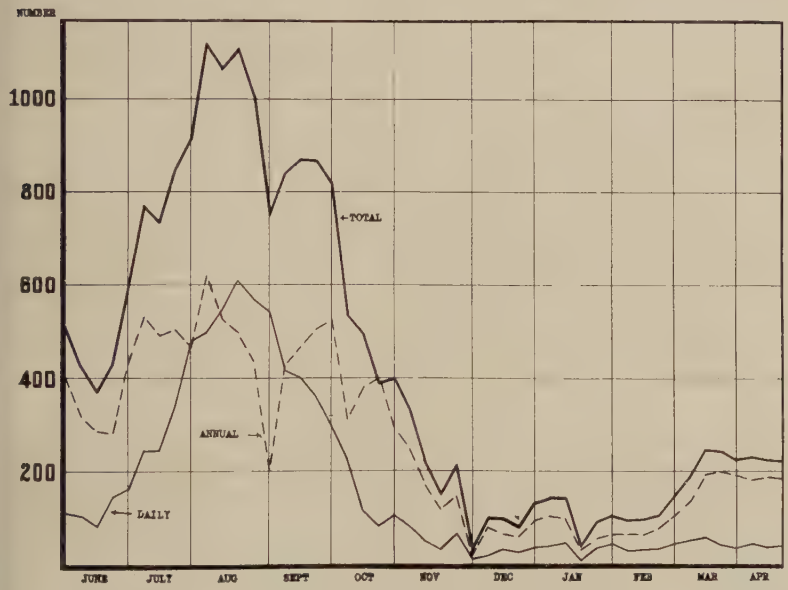

FIGURE 6. Total number of farm trucks on Gardeners' and Farmers' Market, by weeks, and the number operating under daily or annual permits from May 3, 1937, to May 2, 1938.

mid-August and then declined sharply, while producers who purchased permits by the season had a much longer peak movement. The latter have diversified production while many growers who buy daily permits produce only one or two crops for market.

Facilities for out-shipments of locally grown fruits and vegetables are needed for only a comparatively short period during the year. Shipments amounted to 2 to 4 truck loads weekly until the

strawberry season opened. Then they jumped sharply to a peak movement. During the first week of June, 59 truck loads of produce were shipped from the Gardeners' and Farmers' Market.

After the strawberry season was over shipments dropped sharply for most of July and August, again increasing during October when tomatoes, roasting corn, green beans and pears were in season. These data do not show the movement of strawberries bought directly from growers in the County, which were estimated to amount to 50 truck loads, or those sold thru the cooperative shipping association, which were shipped at the same period as other local products and amounted to about 50 carloads. Nor do they show the shipment of potatoes by local exchanges which occurred during the latter part of June and July, and amounted to about 63 carloads by rail and 250 loads by truck. Furthermore, that produce, mostly sweetpotatoes and greens, estimated to be equal to 125 carloads, which was sold at farms directly to truck merchants during the fall and winter was not included. If these shipments were added to those shown in figure 5 they would only emphasize the heavy movement during the strawberry and potato shipping season.

The facilities for handling the railroad receipts, altho scattered widely over the city, are used more continuously thruout the year. (See figure 7.) The peak of the rail receipts is reached in May when 12 percent of the total receipts are accounted for. This movement then falls rapidly until August when locally grown produce is marketed in large quantity. Receipts remain fairly constant thruout the remainder of the year. (See figure 7.) The railroad receipts are unloaded, mainly, in four sections of the city. By far the largest proportion are unloaded on the team tracks at the north end of Floyd, Jackson and Water Streets, or the district closest to the wholesale market. (See figure 2.) Seventy-five percent of the receipts were unloaded in this district. The next district in importance includes unloading tracks of the two principal chain stores and the Louisville and Nashville Railroad Yards at 14th and Broadway, where 22.7 percent of the receipts were unloaded. The present tendency is to unload a larger percentage close to the wholesale district and less in all other sections of the city. (See table 4.) The railroads have inadequate facilities for properly icing and loading

outgoing shipments. However, the cooperative association formed in the spring of 1938 has put in an ice crusher and blower, so that modern loading facilities are now available to its members.

FIGURE 7. Total railroad carlot unloads by months during 1937 and unloads at Floyd, Jackson and Water Streets, and at 14th Street, 9th and Broadway and private sidings.

SUMMARY

The wholesale fruit and vegetable trade of Louisville has increased markedly in recent years, in keeping with the growing population, the increased per capita consumption, and the enlarged trade area of the city. The growth of business has created serious problems in the organization and functioning of the market. The recent rapid development of motor transportation in the shipping of fruits and vegetables has also created new needs for handling and exchange of products. Likewise, an increase in production of locally grown fruits and vegetables beyond the requirements for local consumption now demands facilities and organization for the out movement of locally grown products.

The market has not kept fully abreast of the growing needs for facilities and services, as is likely to be the case in a dynamic situa-

tion. Facilities are widely scattered over the city and in nearby suburban sections. Most wholesale dealers do not have direct railroad service at their places of business and they must move shipped-in produce from distant team tracks over crowded city streets. Generally they do not have modern cooling and storing facilities for perishable products. There is frequent congestion of traffic on and near the farmers' market, likewise inadequate segregating of wholesale and retail trade and insufficient differentiation of the trade in locally grown and distant-grown products. Standardization of grading and packaging and dissemination of market news have made little progress, thus causing much confusion in the exchange of products.

Several developments are indicative of the adaptation of the marketing organization to the changing need of the market. The development and widening of thorofares as well as the expansion and re-arrangement of the facilities of the Gardeners' and Farmers' Market relieve much congestion of traffic in the market place. The development of special facilities for trucking merchants, by the Gardeners' and Farmers' Market Company, helps to differentiate the trade in shipped-in and locally grown products on the Market and provides a more satisfactory place of exchange for products brought by motor truck. New agencies and services are being developed particularly to serve the new types of truck merchant. The recent re-location of a principal wholesale dealer in a spacious building with direct railroad service and modern equipment for storing and handling perishable products means better coordination of shipping and handling facilities. The development of a farmers' cooperative marketing association with washing, grading and other equipment provides for the first time an agency definitely organized for shipping surpluses of locally grown products. Finally, the recently renewed discussion of better marketing among farmers, dealers, officials of the Gardeners' and Farmers' Market, the press, city officials and other interested groups is making for constructive suggestions of market improvements. These and other recent developments are significant of possible future progress in more orderly and efficient wholesale distribution of fruits and vegetables in Louisville.

Kentucky
Agricultural Experiment Station

University of Kentucky

THE FRUIT AND VEGETABLE SUPPLY OF LOUISVILLE

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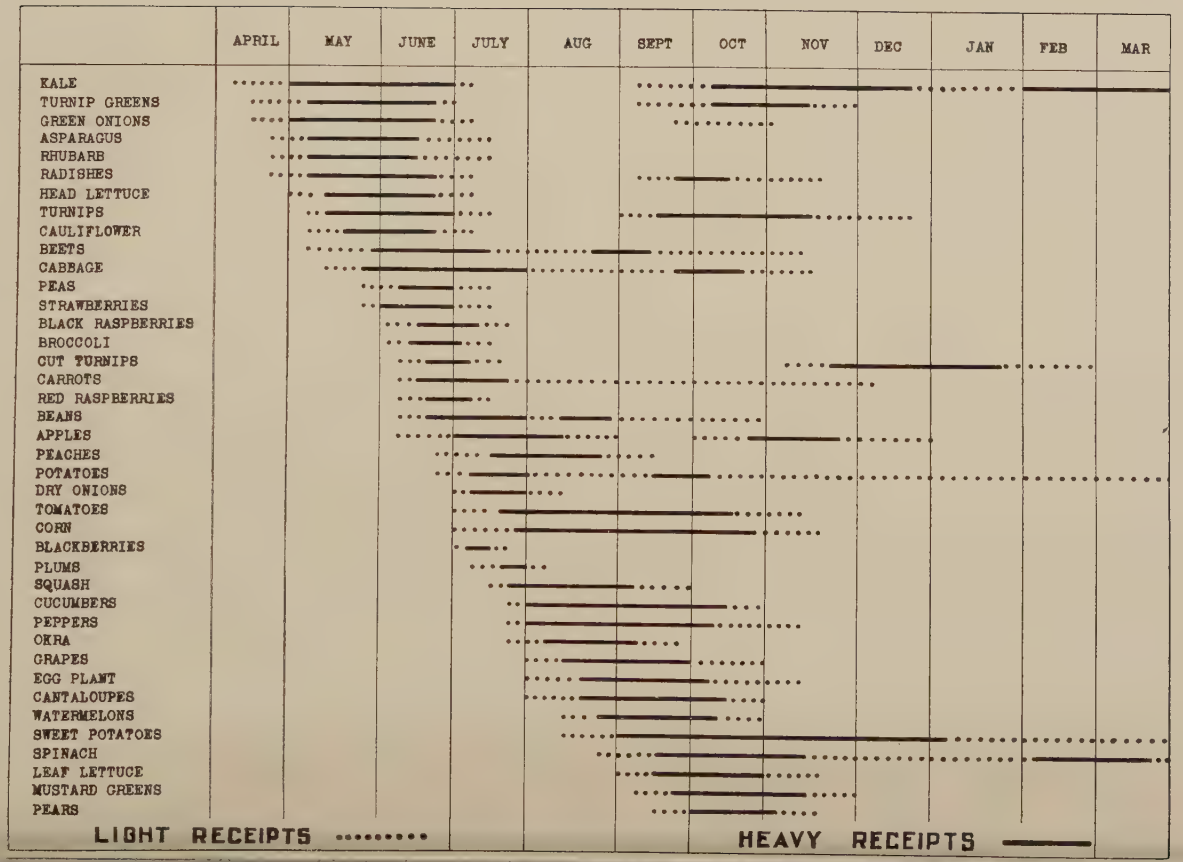
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OKRA
GRAPES
EGG PLANT
CANTALOUPES
WATERMELONS
SWEET POTATOES
SPINACH
LEAF LETTUCE
MUSTARD GREENS
PEARS
LIGHT RECEIPTS .....
HEAVY RECEIPTS ——

Bulletin No. 387

THE FRUIT AND VEGETABLE SUPPLY OF LOUISVILLE

C. D. PHILLIPS*

The consumption of fresh fruits and vegetables in the metropolitan area of Louisville amounted to nearly 11,000 carloads during the 12 months, May 1, 1937, to April 30, 1938. This supply was composed both of locally grown produce and of produce shipped into the market from other producing areas. Locally grown produce accounted for approximately 3,700 carloads of the supply, while of the remainder, 4,627 carloads were shipped into the city by railroads and 2,500 carloads by motor truck. The purpose of this study is to show the various kinds of fruits and vegetables supplied to the market, the state of origin of the receipts, the method of transporting the produce to the market, and the seasonal marketing period of locally grown fruits and vegetables, as well as of produce shipped in from other areas. This study also shows the shipments of locally grown produce out of the market and specifies the markets to which shipments were sent.

Locally grown supplies furnish the market requirements for only a short period during each year. Figure 1 shows the marketing season of the 40 more common fruits and vegetables produced locally during the 1937 season. Most of these fruits and vegetables supplied the requirements of the market during a comparatively short period as indicated in figure 1. For a short period, indicated by the dotted portions of the lines, before and after the peak movement, the supply did not meet market requirements.

The marketing seasons of different locally grown fruits and vegetables showed considerable variation and can be divided into four classifications: (1) products which had a short marketing season lasting only a few weeks during the early part of the summer, such as cauliflower, head lettuce, broccoli, strawberries, raspberries, peaches and plums; (2) products which had a long, continuous marketing season during the late summer and fall, such as corn, tomatoes, sweetpotatoes, eggplant, peppers and squash; (3) products which were marketed almost continuously thruout the summer and fall, but had a heavy marketing period during the early part of the season when the first crop was harvested, and another in the fall

* This publication is based on a study of the Louisville wholesale fruit and vegetable market. For a discussion of the organization of the market see Kentucky Experiment Station Bulletin Number 368, entitled "Organization of the Louisville Wholesale Fruit and Vegetable Market" by H. B. Price, C. D. Phillips and S. E. Wrather.

when the second crop was marketed; vegetables such as cabbage, beets, carrots and potatoes come under this group; (4) vegetables which had two distinct marketing seasons, one in the early spring, after which they completely disappeared from market, and another in the fall and winter when the second crop was being marketed; vegetables such as kale, spinach, turnips, radishes and green onions are marketed in this manner.

At least 26 other fruits and vegetables not shown in figure 1 were marketed in small quantities at some time during the season[1]. Many of these products such as cherries, Chinese cabbage, parsley, dill and bibb lettuce were marketed in very limited quantities and should be classified as specialties. In all probability these specialty products supplied the rather limited demand for this type of produce.

Altho some locally grown fruits and vegetables are marketed in every month of the year, the bulk of the locally grown produce is sold during July, August and September. This is shown by the number of farmers' trucks on the Gardeners' and Farmers' Market during the 1937 marketing season, May 1, 1937, to April 30, 1938. During that period about 23,000 farm truck loads of produce were sold on the Gardeners' and Farmers' Market, by farmers. Fifty-six percent of all the loads, however, were sold during July, August and September, with more than 22 percent sold during August. (See figure 2.) The amount of locally grown produce sold on the market during the winter and early spring depends to a large extent on weather. If the weather is mild, spinach and kale are available in large quantities thruout the winter, but when winter weather is severe, these greens are frozen and the supply is generally reduced or completely destroyed. The amount of greens marketed during March and April also depends largely on weather during the winter. If kale and spinach have been killed by severe freezing during the winter, there are practically no greens marketed during March and April, while if there has been a mild winter, large quantities are usually available for marketing.

Altho the bulk of both early and late potato crops is marketed within a short period after harvesting, there is demand for home-grown potatoes thruout the year. Some producers store potatoes and "feed the market" during the winter and spring, as the

1 May include cherries, pawpaws, persimmons, huckleberries, elderberries, gooseberries, poke greens, Chinese cabbage, chives, kohlrabi, parsley, parsnips, salsify, lima beans, swiss chard, bibb lettuce, blackeyed peas, shell-out beans, pumpkins, dill, sage, sassafras roots, horseradish, popcorn and watercress.

market demands locally produced potatoes. Such potatoes were sold during the past winter at a price varying 20c to 30c per bushel above that of shipped-in potatoes, thus offering an outlet for a limited supply of locally grown potatoes thruout the year.

Sweetpotatoes, also, are marketed chiefly for local consumption. They are stored on the farm and marketed as rapidly as the local market will absorb them. However, some producers prefer to ship their sweetpotatoes to other markets during the season when the main crop is being harvested, rather than to store them, since they are difficult to store satisfactorily on the farm. During the last two seasons the local supply was nearly exhausted by February and the market had to depend on shipped-in supplies after that date. There is a limited demand for sweetpotatoes which are more uniformly graded and more attractively packed than those sold by local producers; consequently, during the fall, even when the bulk of the local crop is being marketed, some are shipped in to meet this trade. These better graded and packed sweetpotatoes sold from 25 to 50 cents a bushel more than locally grown sweet potatoes, during the past year. Buyers indicated they would prefer locally grown sweetpotatoes if they were graded and packed as well as those from elsewhere.

A similar situation exists for practically all locally grown fruits and vegetables. Consequently, many high-quality products from other areas are shipped in for this high-quality trade. Likewise low-quality products from other markets are received to supply the trade which demands a lower-quality produce than the mixed packs usually marketed by local growers. For example, during the past season, many truck loads of "cull" tomatoes were received from other markets and sold at lower prices than were being paid for locally grown tomatoes. Even when locally grown products are in season some fruits and vegetables are received in the market from distant producing areas. To a large extent, these receipts supplement the locally grown produce rather than compete with it. Figure 2 illustrates this situation.

Fruits and vegetables are received in Louisville from every important producing area in the United States as well as from foreign countries as is indicated by the accompanying chart, figure 3. The bulk of the receipts by rail come from areas more distant than truck receipts.

California, Florida, Louisiana and Michigan are the states in

which most of the rail receipts originate (see table 1). After deducting citrus fruit, bananas, pineapples, and other fruits not produced locally, from the total rail receipts, the bulk of the remainder of the fruits and vegetables comes from California, Michigan, Texas, Alabama and New York. The crops in these states are marketed during that part of the year when locally grown produce is not on the local market, or they are the important crops, such as potatoes, which are used thruout the year in larger quantities than local production can supply.

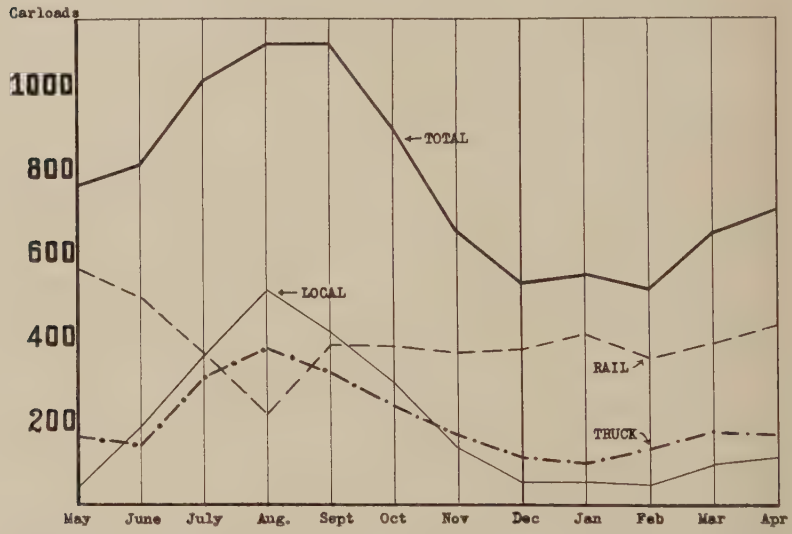

FIGURE 2. Total monthly supply of fruits and vegetables on the Louisville market, divided as to locally grown produce, rail receipts and truck receipts, for the period, May 1, 1937, to April 30, 1938.

During the 1937 marketing season, 35 different fruits and vegetables were shipped into Louisville by railroad in carlot quantities[1]. (See table 2.) Receipts of potatoes were the largest, bananas, oranges, lettuce, apples, cabbage and grapefruit were next in the order of importance.

The heaviest rail receipts are during May and June when receipts of potatoes are largest and shipments of early spring fruits and vegetables, such as strawberries, peas, beans and tomatoes from southern producing areas are at their peak. Receipts drop rapidly during July and reach the lowest point in August when local production is at its peak. Receipts by rail then increase during Sep-

1 Monthly receipts of fruits and vegetables and state of origin are shown in table 8.

tember and remain nearly constant during the remainder of the year. Monthly carlot unloads of the various fruits and vegetables for the 12-month period, May, 1937, to April, 1938, and the total for the preceding 12-month period are shown in table 3.

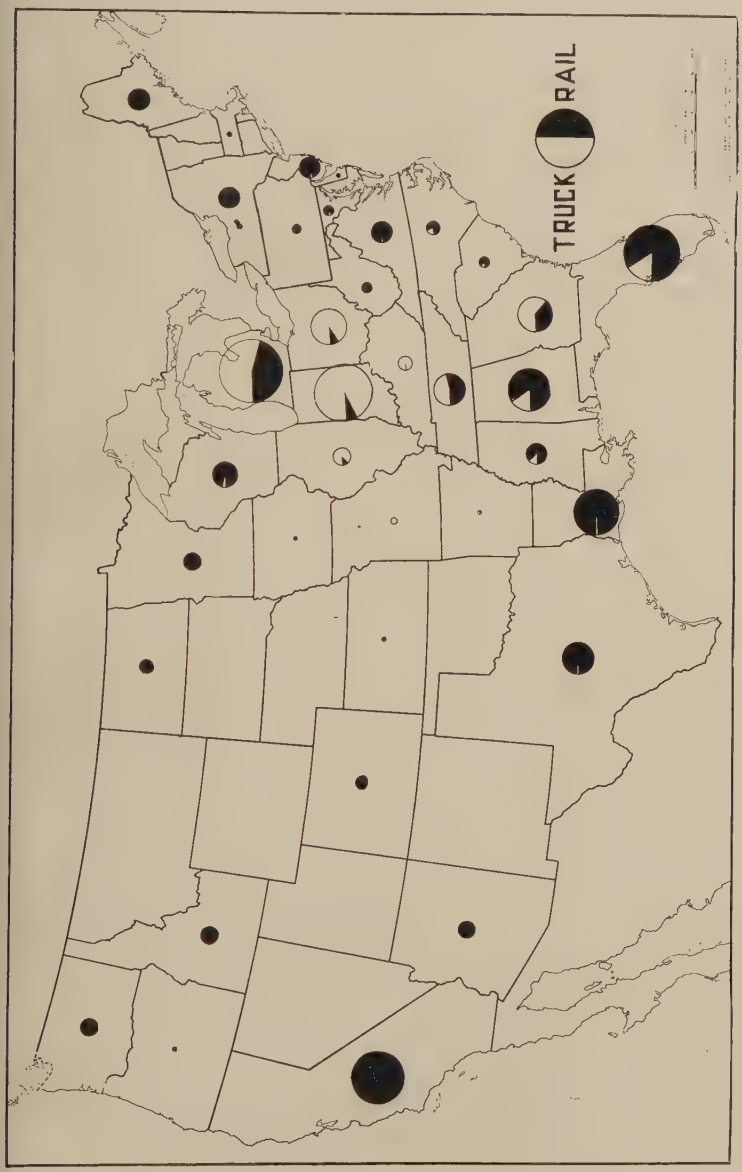

FIGURE 3. State of origin of railroad and truck receipts of fruits and vegetables, in Louisville, during the 12 months, May 1, 1937, to April 30, 1938. (The receipts from Kentucky do not include the fruits and vegetables produced in the Louisville area.)

Table 1. Carlot unloads of fruits and vegetables received by rail at Louisville, 1934-1937, by State of origin.

State of origin	1934	1935	1936	1937
Alabama	383	262	252	339
Arizona	32	100	107	98
Arkansas	3	3	17	4
California	628	685	864	695
Colorado	41	60	93	70
Delaware	2		14	9
Florida	560	539	602	650
Georgia	126	115	141	116
Idaho	132	51	61	69
Illinois	45	58	15	6
Indiana*	69	25	72	55
Iowa	1	2	3	2
Kansas			6	2
Kentucky*		14	17	8
Louisiana	532	868	646	523
Maine	13	12	45	132
Maryland	7	5	47	24
Massachusetts	6	2	3	5
Michigan	290	405	557	462
Minnesota	47	60	70	67
Mississippi	107	75	131	89
Missouri	1	5	18	
New Jersey	32		213	109
New Mexico	9		2	
New York	175	177	186	155
North Carolina	23	34	28	49
North Dakota	8	74	19	45
Ohio	10	15	7	20
Oklahoma		2	6	
Oregon	13	7	5	2
Pennsylvania	25	11	38	35
South Carolina	44	36	85	22
South Dakota		4		
Tennessee	151	106	83	138
Texas	265	234	308	274
Utah		5	3	
Virginia	125	142	147	110
Washington	99	90	93	95
West Virginia	77	79	121	40
Wisconsin	93	116	132	129
Mexico			1	6
Ontario, Canada			4	
District of Columbia			2	
Total	4,174	4,478	5,257	4,654

* Does not include fruits and vegetables produced in the Louisville area.

Table 2. Carload unloads of fruits and vegetables received by rail at Louisville, 1934-1937 by kind. *

Commodity	1934	1935	1936	1937	Average 1934-1937
Apples	356	377	408	259	350.0
Bananas	593	728	697	554	643.0
Beans	88	70	72	32	65.5
Cabbage	303	247	314	258	280.5
Cantaloupes	55	56	68	56	58.75
Carrots	22	25	44	32	30.75
Cauliflower	59	52	57	60	57.0
Celery	69	106	86	91	88.0
Cherries	1			1	.5
Corn	41	59	15	16	32.75
Coconuts		6	5		2.75
Cranberries	3	2	2	8	3.75
Cucumbers		2	5		1.75
Figs		1			.25
Grapefruit	95	125	132	212	141.0
Grapes	62	79	84	75	75.0
Honeydew Melons	8	19	10	28	16.25
Kale	18	15	4	46	20.75
Lemons	85	93	108	60	86.5
Lettuce	232	283	310	289	278.5
Mixed Greens				6	1.5
Mixed Vegetables	129	127	110	53	104.75
Onions	224	217	253	171	216.25
Oranges	427	435	470	415	436.75
Parsley	1				.25
Peaches	43	53	69	26	47.75
Pears	14	12	25	19	17.5
Peas	23	11	19	27	20.0
Pineapples	13	17	16	22	17.0
Plums	1	1	2	1	1.25
Prunes	3	4	2	1	2.5
Potatoes	855	872	1,406	1,422	1138.75
Rutabagas		1			.25
Satsumas	1		1		.5
Spinach	9	1	11	10	7.75
Strawberries	34	26	4	31	23.75
Sweetpotatoes	25	32	72	52	45.25
Tangerines	19	12	24	19	18.5
Tomatoes	137	144	171	154	151.5
Turnips			2	1	.75
Walnuts			1		.25
Watermelons	126	168	174	147	153.75
Total	4,174	4,478	5,257	4,654	4,639.75

* Does not include fruits and vegetables produced in the Louisville area.

Table 3. Carlot unloads, by months of all fruits and vegetables received at Louisville by Rail.

Commodity	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	1937-38	1936-37
Apples	19	1	3	3	22	29	17	24	18	13	20	34	203	434
Bananas	65	57	44	48	51	39	28	22	56	44	52	69	575	667
Beans	11	11	3	1		1	1		2	1	3	7	41	65
Cabbage	30	1	6	9	12	29	29	30	31	23	11	22	233	289
Cantaloupes		29	20	1	5	1						56	56	68
Carrots	7	1			1	4	3	3	4	2	5	6	36	45
Cauliflower	3	1		2	5	3	6	10	3	4	1	8	46	57
Celery	11	4				2	14	17	9	11	9	11	88	83
Cherries						1							1	
Coconuts														5
Corn	3	6	2										16	15
Cranberries							3	5	1				9	2
Cucumbers														5
Grapefruit	20	4	1		8	20	19	18	20	21	33	21	185	189
Grapes				8	19	26	15	7	1				76	84
Honeydew Melons		1	17	5	3	2							28	10
Kale								2	8	14	6		32	44
Lemons	9	15	11	6	3	1	2	2	4	4	5	5	67	96
Lettuce	31	22	26	21	21	19	29	31	29	24	21	10	282	279

Mixed Greens	2											1	3	4
Mixed Vegetables	3		3		2	6	5	2	2	4	4	6	37	83
Onions	25	10	4	12	21	16	20	11	23	15	8	10	175	221
Oranges	47	22	18	21	19	27	44	72	53	47	55	40	465	435
Peaches		4	11	1	10								26	69
Pears		1	1	7	9	1							19	25
Peas	11	4	5	2									22	18
Pineapples	11	7									1	2	21	18
Plums		1											1	2
Prunes					1								1	2
Potatoes	190	223	36	59	163	135	102	91	110	89	108	127	1433	1404
Spinach	1							1	4				6	9
Strawberries	17								1	7	5	10	40	17
Sweetpotatoes	1		4	3		5	8	5	7	3	6	2	44	70
Tangerines							1	10	6	1			18	28
Tomatoes	36	53	11			5	9	3	6	14	25	30	192	173
Turnips									1		2		3	2
Walnuts														1
Watermelons	1	10	129	7									147	174
1937-38	559	488	355	216	375	372	355	366	399	341	380	421	4627	
1936-37	521	528	421	339	489	512	421	381	331	319	475	443		5195

Receipts of fruits and vegetables by motor truck have shown a considerable increase during the past few years. During the 12 months, May 1, 1937, to April 30, 1938, about 6,000 truck loads of fruits and vegetables or the equivalent of 2,500 carloads were brought into Louisville by this method of transportation. As shown in figure 3 and table 4, receipts of fruits and vegetables by truck originated in 23 different states. The neighboring State of Indiana was the most important, but a large number of loads was also received from the more distant states of Michigan, Florida and Georgia. Table 4 shows the state of origin with the number of truck loads from each, received in Louisville during the period covered by this study. The various commodities, converted into carload equivalents by months, are shown in table 5.

Many truck merchants do not go to producing areas for loads, but buy fruits and vegetables at some terminal or regional market. Thus truck receipts from certain states do not include produce grown within their borders alone. The receipts from Ohio, for example, do not represent only produce grown in Ohio, because many truck loads of produce were bought on the Cincinnati Fruit and Vegetable Auction Market and then transported to Louisville by truck. Also many of the receipts credited to Georgia, were composed of produce grown in Florida or other southern state and brought into the regional market at Atlanta, either by truck or rail, and then purchased by truck merchants who transported it to Louisville.

During the period covered by this study about 60 percent of the truck receipts were brought into Louisville by trucker merchants and sold by them on the Gardeners' and Farmers' Market. The other 40 percent were handled by established local dealers who obtained their produce in several different ways. First, they brought produce into Louisville in their own trucks, from the locality of purchase; second, they purchased from commission dealers in other markets and hired truck transportation; third, they bought entire loads from some itinerant truck merchant, or, fourth, they handled the loads of itinerant truck merchants, on a commission basis.

During the period, July 1 to September 4, 1937, 217 different trucker merchants brought loads into Louisville and sold the produce on the Gardeners' and Farmers' Market. At least 20 of the

established fruit and vegetable dealers handled trucked-in produce, while six firms handled practically all of the produce shipped into the market by rail.

Rail receipts are handled by firms which have facilities to handle and store large quantities of produce. On the other hand, much of the trucked-in produce is sold directly from trucks and no facilities are used other than a place to park. However, as the volume of produce brought into Louisville by motor truck is increasing, and as a greater variety of produce is now being transported by truck than was the case a few years ago, it is becoming increasingly important that better facilities to handle these truck receipts be developed. The lack of facilities distinctly limits the amount of produce brought in by truck to that which can be consumed before spoilage takes place. With apples this extends over a longer period than with the more perishable products such as tomatoes and beans. To a large extent it is because of the lack of proper facilities for handling the produce that only the less perishable products are brought into Louisville by motor truck.

The seasonal movement of truck receipts is similar to that of the home grown produce and somewhat the reverse of the receipts by rail (see figure 2). Truck receipts are low in May, when rail receipts are highest, while the highest truck receipts occur in August when rail receipts are lowest. This situation should be expected, however, when we remember that most of the truck receipts originate in states close to Kentucky, where the season of production is somewhat similar to that for the commodities produced in the local area. Truck receipts are low in winter, when weather conditions are uncertain and road conditions hazardous, but increase as soon as the southern crop becomes available. Weather conditions existing in December, January and February are a handicap for this mode of transportation during this period; however, with better roads and with trucks better equipped to protect cargoes from inclement weather, this condition will undoubtedly be overcome, to some extent at least.

Shipments of Fruits and Vegetables. The Louisville producing area is favorably situated to supply the needs of many large industrial centers located to the north and east of Louisville, for certain fruits and vegetables, since during a short period after the produc-

tion season in the southern areas is ended and before produce from the northern areas becomes available, there is a demand for products grown in the Louisville area. Thus during this period buyers from these Northern and Southern markets come to Louisville for greens, strawberries, beets, turnips, carrots, peas, early peaches, po-

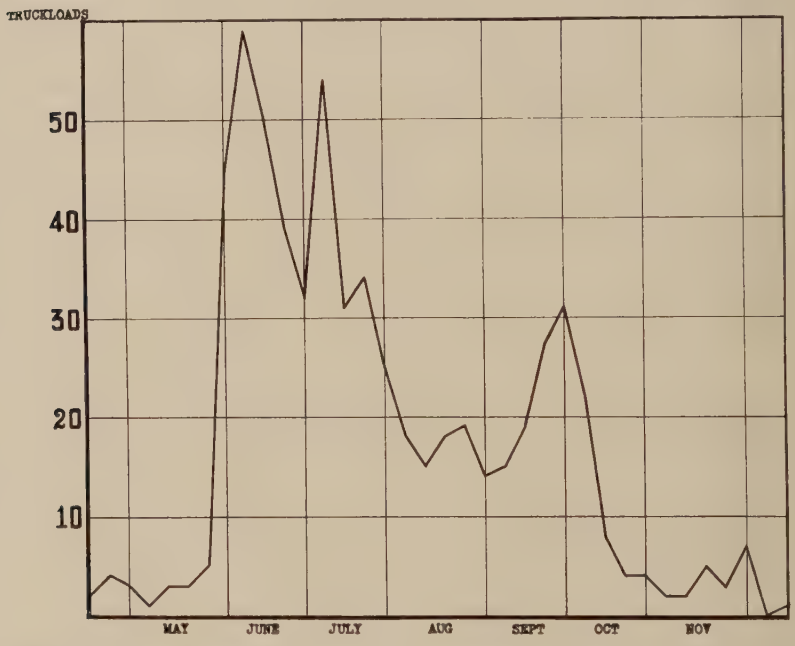

FIGURE 4. Truck shipments of fruits and vegetables from Louisville during the 1937 season.

tatoes and tomatoes. The demand for these products from this area is largest early in the production season and decreases as the season progresses and vegetables from the northern producing areas, which are closer to these cities, become available. Altho some produce is shipped out of the market during most months of the year, the largest shipments normally occur in the last half of May, June and early July when greens, strawberries, early beets, carrots, cabbage and potatoes are being harvested locally. The seasonal movement of shipments is illustrated in figure 4 which shows the movement of 619 loads purchased by itinerant truck merchants on the Gar-

Table 4. State of origin of motor-truck receipts of fruits and vegetables at Louisville, from May 1, 1937, to April 30, 1938, and number of truck loads received monthly from each state.

	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Alabama	80	17	10	10	..	..	3	..	..	..	..	39	157
Arkansas	..	..	2	..	..	..	..	..	..	..	1	..	3
Florida	33	3	4	..	..	3	6	9	29	42	90	95	314
Georgia	43	45	185	34	1	5	14	22	14	13	42	84	502
Illinois	9	16	20	32	23	19	16	11	6	2	2	2	158
Indiana	24	31	195	559	378	246	143	62	44	33	34	16	1765
Kentucky	6	15	46	81	6	4	..	3	7	..	..	2	170
Louisiana	..	2	..	..	..	..	..	1	..	..	1	..	4
Maryland	..	..	2	2	..	..	..	..	..	..	..	..	4
Michigan	39	12	23	68	233	227	135	112	91	131	119	79	1269
Mississippi	12	21	..	..	..	1	3	..	..	..	..	..	37
Missouri	..	1	11	18	..	1	..	..	..	..	..	..	31
New Jersey	..	..	..	2	..	..	..	..	..	..	..	..	2
New York	..	..	..	..	..	..	..	..	1	1	..	..	2
North Carolina	..	4	6	..	6	8	2	..	..	..	..	..	26
Ohio	68	71	57	54	71	55	47	61	44	59	63	59	709
Pennsylvania	..	..	..	..	1	..	..	..	..	..	..	..	1
South Carolina	..	..	4	..	1	1	..	1	1	..	..	..	8
Tennessee	42	107	58	17	1	..	1	..	..	1	9	12	248
Texas	1	1	..	..	..	..	..	..	..	1	..	..	3
Virginia	1	..	1	1	..	..	..	..	..	..	..	..	3
West Virginia	..	..	..	..	..	1	..	..	..	..	..	..	1
Wisconsin	..	1	2	3	..	1	1	..	2	..	..	1	11
	358	347	626	881	721	572	371	282	239	283	361	387	5428

Table 5. Receipts of fruits and vegetables by motor truck in Louisville, in carlot equivalents, from May 1, 1937 to April 30, 1938.

	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Apples	2.6	8.8	21.2	30.7	79.6	97.9	76.2	48.8	36.3	57.4	59.5	30.6	549.6
Asparagus	1.0	..	..	..	..	..	..	..	..	..	..	..	1.0
Beans	21.5	16.4	9.1	3.4	1.9	1.4	3.5	1.2	4.4	3.7	10.7	19.6	96.8
Beets	..	..	.4	.4	.3	.2	..	..	..	..	..	..	1.3
Broccoli	..	..	..	..	..	.1	.2	.2	..	..	..	..	.5
Brussels sprouts	..	..	..	..	.1	.1	.3	.4	..	..	..	..	.9
Cabbage	15.3	4.2	10.9	2.8	20.3	28.1	4.6	..	1.5	7.3	21.8	25.2	142.0
Cantaloupes	..	5.4	48.6	48.5	1.3	.1	..	..	..	..	..	..	103.9
Carrots	..	..	1.5	4.3	1.9	.1	..	..	..	.2	..	..	8.0
Cauliflower	..	.1	.2	..	.1	.1	.1	..	..	..	..	.1	.7
Celery	..	1.9	4.3	6.4	8.1	11.6	11.3	8.0	1.4	.1	.4	..	53.5
Celery Hearts	..	..	..	..	.3	1.5	2.7	.6	..	..	..	..	5.1
Cherries	..	.5	..	..	..	..	..	..	..	..	..	..	.5
Coconuts	..	..	..	..	..	.1	..	..	..	..	..	..	.1
Corn	.2	4.2	2.1	6.2	1.4	1.0	..	..	..	..	..	..	15.1
Cranberries	..	..	..	..	..	.3	.1	..	..	..	..	..	.4
Cucumbers	1.0	3.8	4.0	.2	.9	.1	..	..	..	..	..	.1	10.1
Dates	..	..	..	..	..	..	.4	..	..	..	..	..	.4
Egg plant	.2	..	..	..	..	..	..	..	..	..	.1	..	.3
Grapefruit	.8	..	..	..	.3	.3	1.0	.2	.8	.9	1.2	1.1	6.6
Grapes	..	..	.1	.8	2.3	9.8	..	..	..	..	..	..	13.0
Honeydews	..	.1	3.1	.3	.1	..	..	..	..	..	..	..	3.6
Kale	..	.1	..	.4	.5	.2	..	..	..	..	..	..	1.2
Lemons	.4	1.2	2.1	.5	.1	.3	.1	.2	..	..	..	..	4.9
Lettuce	5.0	4.4	2 9	2.4	.4	.2	.5	.7	..	..	..	..	16.5
Lima beans	.3	2.0	3.1	1.2	4.5	..	..	..	..	.1	..	1.0	12.2
Limes	.6	.7	.3	.1	.1	.4	..	.4	..	..	..	..	2.6

Miscellaneous	.1	.1	..	..	..	..	..	..	..	..	..	..	.2
Mixed Vegetables	15.3	19.3	21.7	21.7	26.0	29.7	23.7	21.7	19.3	23.0	28.3	35.3	285.0
Mustard	.1	.1	..	..	.1	..	..	..	..	..	..	..	.3
Onions	.2	1.6	1.4	2.5	2.1	5.6	5.8	1.8	2.5	1.9	3.0	3.5	31.9
Oranges	2.9	2.5	2.5	.4	.2	.3	3.9	6.0	5.5	4.3	10.2	4.5	43.2
Parsnips	..	..	..	.3	.4	.2	.2	.2	..	..	..	..	1.3
Peaches	..	1.6	10.4	54.2	34.5	2.9	..	..	..	..	..	..	103.6
Peas	1.2	.1	..	..	.1	..	..	.1	..	..	..	.3	1.8
Pears	..	..	.8	.8	1.4	3.6	1.1	.2	..	..	..	..	7.9
Pecans	..	..	..	..	..	..	1.8	1.2	..	..	..	..	3.0
Peppers	.5	.3	.7	.1	.3	.1	.9	..	..	.2	.2	..	3.3
Pineapples	1.0	1.0	..	..	..	..	..	..	..	..	..	..	2.0
Plums	..	.3	.4	.4	.9	..	..	..	..	..	..	..	2.0
Potatoes	30.2	24.4	25.9	16.6	17.6	27.4	21.6	12.5	20.0	20.7	19.9	13.3	250.1
Radishes	.6	3.4	.1	..	.1	.3	.2	.1	..	..	.3	..	5.1
Rhubarb	3.8	.3	..	..	..	..	..	..	..	..	..	..	4.1
Rutabagas	..	..	..	..	.1	.2	.2	.3	..	..	..	..	.8
Shallots	..	..	..	..	..	.1	.1	.1	..	..	..	..	.3
Spinach	1.4	.8	..	..	.4	..	..	.2	..	..	..	.5	3.3
Squash	.2	.3	..	..	..	..	.1	.1	..	.1	.2	..	1.0
Strawberries	43.1	2.0	..	..	..	..	..	..	1.8	3.6	3.0	17.0	70.5
Sweetpotatoes	3.1	2.4	.6	3.3	.8	..	.4	3.3	..	.4	2.4	4.0	20.7
Tangerines	..	..	..	..	..	..	.1	.5	1.0	.6	..	..	2.2
Tomatoes	7.7	17.4	16.0	1.4	1.0	3.2	.1	.8	.5	3.1	4.4	8.5	64.1
Turnips	..	.2	.1	..	..	..	..	..	..	.1	1.0	..	1.4
Watermelons	.3	6.9	103.8	157.7	99.8	5.2	..	..	..	..	..	..	373.7
Turnip greens	..	..	..	..	..	..	..	..	.3	..	.4	.8	1.5
Total	160.6	138.8	298.3	368.0	310.3	232.7	161.2	109.8	95.3	127.7	167.0	165.4	2335.1

deners' and Farmers' Market during the 1937 season. The produce which composed these shipments is shown in table 6.

In addition to these shipments which were equivalent to 210 carloads the author estimated that the equivalent of 125 carloads of potatoes were shipped out by the potato exchanges, 50 carloads of strawberries by the cooperative strawberry association, and 20 carloads of strawberries, 100 carloads of greens and 25 carloads of sweetpotatoes which were purchased in the country directly from

FIGURE 5. Location of markets which received shipments of fruits and vegetables by truck during 1937, from Louisville.

producers, by itinerant truck merchants. By far the largest portion of these out shipments, or 348 carloads, were transported to other markets by motor truck while only 47 carloads were shipped by rail.

Table 6. Fruits and vegetables purchased by itinerant truck merchants on the Gardeners' and Farmers' Market, for shipment to other markets, during the 1937 marketing season.

	April 15-30	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Apples, bushels	..	..	653	1698	547	438	275	162	..	3793
Bananas, bunches	..	..	..	27	52	..	..	..	..	79
Beans, bushels	..	..	269	287	351	2008	326	..	..	3241
Beets, doz. bunches	..	..	8634	476	3	4	..	20	..	9137
Berries, (except strawberries), crates	..	..	1922	885	..	..	..	..	..	2807
Blackeyed peas, shelled gals.	..	..	..	..	..	2	5	..	..	7
Broccoli, peck baskets	..	..	30	..	..	..	..	..	..	30
Cabbage, bushels	..	..	16119	632	243	216	224	..	..	17434
Cantaloupes, bushels	..	..	..	623	1075	241	..	..	..	1939
Carrots, doz. bunches	..	..	2827	220	2	6	..	..	..	3055
Cauliflower, bushels	..	..	324	..	..	1	..	..	..	325
Celery, crates	..	..	..	..	3	20	3	..	..	26
Corn, bushels	..	..	83	6082	852	696	207	..	..	7920
Cucumbers, bushels	..	..	58	542	348	45	6	..	..	999
Cut beets, bushels	..	..	2	21	..	..	..	..	..	23
Cut turnips, bushels	..	..	180	10	..	2	60	10	..	262
Dill, tons	..	..	..	..	..	1	..	..	..	1
Eggplant, bushels	..	..	..	1	23	65	60	..	..	149
Grapefruit, crates	..	..	..	..	..	..	4	..	..	4
Grapes, peck basket	..	..	12	507	341	67	..	..	..	927
Green onions, doz. bunches	..	..	33	11	..	32	..	..	..	76
Greens, bushels	2384	2084	59	1	1	325	462	1963	1180	8459
Kohlrabi, bushels	..	..	..	31	..	..	..	..	..	31
Lemons, crates	..	..	..	2	16	..	..	..	..	18
Lettuce, crates	..	..	36	6	9	47	..	1	..	99
Lima beans, bushels	..	..	70	12	15	9	26	..	..	132
Okra, ½ bushels	..	..	..	..	..	8	4	..	..	12
Onions, dry, bushels	..	..	104	566	18	155	5	..	..	848
Oranges, crates	..	..	..	4	7	2	3	2	..	18
Parsley, bushels	..	..	109	60	..	..	..	..	..	169
Pawpaws, crates	..	..	..	..	..	4	..	..	..	4
Peaches, bushels	..	..	57	1609	1802	125	..	..	..	2873
Pears, bushels	..	..	..	5	1	569	504	9	..	1088
Peas, bushels	..	..	2638	..	..	..	..	..	..	2638
Peppers, bushels	..	..	1	143	164	339	92	..	..	738
Persimmons, crates	..	..	..	..	..	..	1	..	..	1
Plums, bushels	..	..	..	14	8	30	3	..	..	55
Popcorn, bushels	..	..	..	..	..	..	21	..	..	21
Potatoes, bushels	..	..	143	350	81	79	79	217	..	949
Radishes, 3 doz. bunches	..	..	..	..	..	6	..	..	..	6
Shell-out beans, bushels	..	..	..	7	2	9	..	..	..	18
Squash, bushels	..	..	5	113	79	56	39	..	..	292
Strawberries, crates	..	2781	8245	69	..	..	..	..	..	11091
Sweetpotatoes, bushels	..	..	1	27	503	390	..	..	25	946
Tomatoes, ½ bushels	..	..	198	720	564	1425	169	3	..	3079
Turnips, doz. bunches	..	..	2567	130	..	171	965	..	15	3849
Watermelons	..	..	529	3492	1450	50	..	..	..	5521

The bulk of the produce shipped from the area went to markets in states to the north and east of Louisville altho some went to markets within the State and to southern cities. Markets which received shipments are shown in figure 5, and table 7 shows the number of loads which each received. From an examination of figure 5, it can be seen that produce from the Louisville area has a comparatively wide distribution, but there are many more cities within easy trucking distance of Louisville that could be developed as possible outlets for locally grown produce. Before there is much expansion, however, it will be important for local produce to be graded and packed in a better manner, so that buyers from other markets can

Table 7. Cities to which produce from the Louisville area was transported by itinerant trucker merchants, in 1937, and the number of loads to each.

Lexington, Ky.	161	Evansville, Ind.	2
Indianapolis, Ind.	90	Huntington, W. Va.	2
Dayton, Ohio	63	Winchester, Ky.	2
Chicago, Ill.	54	Elizabethtown, Ky.	2
Frankfort, Ky.	52	Glasgow, Ky.	2
Cincinnati, Ohio	38	Richmond, Ky.	1
Grand Rapids, Mich.	32	Hazard, Ky.	1
Milwaukee, Wis.	12	Cox Creek, Ky.	1
Atlanta, Ga.	12	Jackson, Miss.	1
Cleveland, Ohio	11	Mobile, Ala.	1
Vincennes, Ind.	11	Montgomery, Ala.	1
Kalamazoo, Mich.	8	Jacksonville, Ill.	1
South Bend, Ind.	7	St. Louis, Mo.	1
Bloomington, Ind.	6	Ft. Wayne, Ind.	1
Lansing, Mich.	5	Bedford, Ind.	1
Terre Haute, Ind.	5	Salem, Ind.	1
Columbus, Ohio	5	Pekin, Ind.	1
Detroit, Mich.	4	Newberry, Ind.	1
Hamilton, Ohio	4	Flint, Mich.	1
Madison, Ind.	3	Harrodsburg, Ky.	1
Muncie, Ind.	3	Stanford, Ky.	1
Ashland, Ky.	2	Liberty, Ky.	1
Charleston, W. Va.	2	Somerset, Ky.	1
		Whitley City, Ky.	1

buy with greater assurance. It will also be important to develop a system of market news service to keep the buyers informed concerning supplies, and prices on the Louisville market[1].

1 For a complete discussion of grades and packaging and the organization of the Louisville Wholesale Fruit and Vegetable Market refer to Kentucky Experiment Station Bulletin Number 368.

Table 8. Receipts of fruits and vegetables at Louisville, May 1, 1937, to April, 1938, exclusive of those grown in the Louisville area.

APPLES

By truck (bushels)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ill.	12	5	75	400	2812	1495	1490	325	275	56	475	485	7,905
Ind.	..	..	10364	5096	19012	30736	20531	10762	6492	6073	6107	2542	117,715
Ky.	..	1095	200	240	160	..	..	..	..	..	..	..	1,695
Mich.	527	150	..	8251	17144	19126	15261	16309	11388	22407	21818	12125	144,506
Ohio	.	..	..	..	..	..	..	..	..	200	1338	158	1,696
Tenn.	..	3242	..	..	..	..	190	..	..	..	..	..	3,432
Total by truck	539	4492	10639	13987	39128	51357	37472	27396	18155	28736	29738	15310	276,949

By rail (carloads)

Calif.	..	..	1	1	..	..	..	..	..	..	..	..	2
Del.	..	..	1	..	..	..	1	..	..	..	..	..	2
Idaho	..	..	..	..	..	..	..	..	2	..	..	..	2
Md.	..	..	1	..	9	1	2	5	3	1	1	..	23
Mich.	..	..	..	..	2	5	1	..	..	..	..	1	9
N. Y.	..	..	..	1	..	..	..	..	..	1	1	2	5
Ohio	..	..	..	..	..	..	1	..	..	..	..	..	1
Pa.	..	..	..	..	..	..	..	1	1	1	..	2	5
Wash.	19	1	..	..	1	7	6	11	5	4	6	7	67
Va.	..	..	..	1	8	6	4	5	4	4	11	21	64
W. Va.	..	..	..	..	2	10	2	2	3	2	1	..	22
D. C.	..	..	..	..	..	..	..	..	..	..	..	1	1
Total by rail	19	1	3	3	22	29	17	24	18	13	20	34	203
Total by truck (carload equivalent)	1.1	9.0	21.1	28.0	78.3	102.7	74.9	54.8	36.3	57.5	59.5	30.6	553.8
Total carloads	20.1	10.0	24.1	31.0	100.3	131.7	91.9	78.8	54.3	70.5	79.5	64.6	756.8

BANANAS

By rail (carloads)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ala.	6	5	4	4	7	..	3	5	3	11	18	28	94
Fla.	5	..	..	..	..	1	..	2	4	..	..	1	13
La.	53	52	40	44	44	38	25	15	40	29	31	38	449
S. C.	1	..	..	..	..	..	..	..	7	4	3	2	17
N. Y.	..	..	..	..	..	..	..	..	2	..	..	..	2
Total by rail	65	57	44	48	51	39	28	22	56	44	52	69	575

BEANS

By truck (bushels)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ala.	215	470	200	..	..	..	..	..	..	..	..	..	885
Fla.	5652	615	..	..	..	..	1465	788	2210	2024	5849	8238	26,841
Ga.	4025	750	400	..	..	..	450	135	53	70	186	3040	9,109
Ill.	..	..	240	..	..	..	5	..	..	..	..	..	245
Ind.	125	75	1532	1846	768	336	..	..	..	..	..	..	4,682
Ky.	..	..	220	100	22	..	..	..	..	..	..	..	342
Md.	..	..	477	..	..	..	..	..	..	..	..	..	477
Mich.	..	..	376	..	..	32	..	..	..	..	..	..	408
Miss.	2235	1037	..	..	..	200	650	..	..	..	..	..	4,122
Mo.	..	..	200	..	..	..	..	..	..	..	..	..	200
N. C.	..	..	200	..	..	100	..	..	..	..	..	..	300
Ohio	94	..	..	..	..	..	..	..	..	..	90	..	184
Tenn.	698	7112	1797	..	236	..	..	..	..	..	..	..	9,843
Total by truck	13044	10059	5642	1946	1026	668	2570	923	2263	2094	6125	11278	57,638

By rail (carloads)

Ala.	1	..	..	..	..	..	..	..	..	..	..	..	1
Colo.	..	..	1	1	..	..	..	..	..	..	..	..	2
Fla.	1	..	..	..	..	..	..	..	..	1	1	6	9
Ind.	..	2	1	..	..	..	..	..	..	..	..	..	3
La.	3	2	..	..	..	..	..	..	..	..	..	..	5
Miss.	6	6	..	..	..	1	1	..	..	..	..	..	14

Pa.	..	..	1	..	..	..	..	..	1	..	..	..	2
Va.	..	1	..	..	..	..	..	..	..	..	..	..	1
Md.	..	..	..	..	..	..	..	..	1	..	..	..	1
Texas	..	..	..	..	..	..	..	..	..	..	1	..	1
Total by rail	11	11	3	1	..	1	1	..	2	1	2	6	39
Total by truck (carload equivalent)	22.7	17.5	9.8	3.4	1.8	1.2	4.5	1.6	3.9	3.6	10.6	19.6	100.2
Total	33.7	28.5	12.8	4.4	1.8	2.2	4.5	1.6	5.9	4.6	12.6	25.6	139.2

CANTALOUPES

By truck (bushels)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ala.	..	250	..	..	..	..	..	..	..	..	..	..	250
Ga.	..	1669	18134	225	..	..	..	..	..	..	..	..	20,028
Ill.	..	167	450	1245	38	75	..	..	..	..	..	..	1,975
Ind.	..	65	12375	25107	740	..	..	..	..	..	..	..	38,287
La.	..	250	..	..	..	..	..	..	..	..	..	..	250
Mo.	..	..	665	3037	..	..	..	..	..	..	..	..	3,702
Tenn.	..	..	240	..	..	..	..	..	..	..	..	..	240
Total by truck	..	2401	31864	29614	778	75	..	..	..	..	..	..	64,732

By rail (carloads)

Ariz.	..	2	7	..	..	..	..	..	..	..	..	..	9
Calif.	..	27	11	..	..	..	..	..	..	..	..	..	38
Ga.	.	..	2	..	..	..	..	..	..	..	..	..	2
Colo.	..	..	..	1	5	1	..	..	..	..	..	..	7
Total by rail	..	29	20	1	5	1	..	..	..	..	..	..	56
Total by truck (carload equivalent)		4.0	53.1	49.4	1.3	.1	..	..	..	..	..	..	107.9
Total	..	33.0	73.1	50.4	6.3	1.1	..	..	..	..	..	..	163.9

CABBAGE

By truck (tons)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Fla.	21.5	..	..	..	..	..	..	..	4.5	66.0	157.25	30.5	279.75
Ga.	135.0	..	5.0	..	..	..	..	..	8.0	18.25	97.5	272.0	535.75
Ill.	..	..	7.0	..	..	.25	5.0	..	..	..	..	..	12.25
Ind.	..	..	39.5	15.0	22.25	133.25	..	..	..	..	..	..	210.00
Mich.	..	..	24.0	7.0	113.0	139.5	19.0	..	..	..	2.5	..	305.00
Miss.	32.0	..	..	..	..	..	..	..	..	..	..	..	32.00
N. C.	..	..	..	..	39.0	36.25	12.5	..	..	..	..	..	87.75
N. Y.	..	..	..	..	..	..	..	..	..	3.75	..	..	3.75
Ohio	..	..	..	3.0	..	..	..	..	..	..	..	..	3.00
Pa.	.	..	..	..	6.5	..	..	..	..	..	..	..	6.50
S. C.	..	..	..	..	..	..	..	..	5.0	..	..	..	5.00
Tenn.	37.25	50.75	..	..	..	..	..	..	..	..	5.0	..	93.00
Va.	..	..	..	5.0	..	..	..	..	..	..	..	..	5.00
Wis.	..	..	15.5	5.5	..	..	..	..	..	..	..	..	21.00
Total by truck	225.75	50.75	91.0	35.5	180.75	309.25	36.5	..	17.5	88.0	262.25	302.5	1599.75

By rail (carloads)

Ala.	..	..	..	..	..	..	..	..	..	..	1	2	3
Fla.	..	..	..	..	..	..	..	..	..	..	2	4	6
Ind.	..	..	1	..	..	..	..	..	..	..	..	..	1
La.	2	..	..	..	..	..	..	..	..	..	1	1	4
Miss.	25	1	..	..	..	..	..	..	..	..	..	15	41
Mich.	..	..	..	2	..	4	..	..	..	..	..	..	6
N. J.	..	..	..	..	..	..	..	1	..	..	..	..	1
N. Y.	..	..	..	1	6	13	29	27	14	3	..	..	93
Ohio	..	..	3	3	..	..	..	..	..	..	..	..	6
Tenn.	3	..	..	..	..	..	..	..	..	..	..	..	3
Texas	..	..	..	..	..	..	..	..	17	20	7	..	44
Wis.	..	..	2	3	6	12	..	2	..	..	..	..	25
Total by rail	30	1	6	9	12	29	29	30	31	23	11	22	233

Total by truck (carload equivalent)	18.8	4.2	7.6	3.0	15.1	25.8	3.0	..	1.5	7.3	21.8	25.2	133.3
Total	48.8	5.2	13.6	12.0	27.1	54.8	32.0	30.0	32.5	30.3	32.8	47.2	366.3

CARROTS

By truck (dozen bunches)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ill.	..	100	1750	..	100	..	..	..	..	..	..	..	1950
Ind.	..	..	1598	1840	302	300	..	..	..	..	..	..	4040
Mich.	..	..	..	600	..	..	..	..	..	..	..	..	600
Ohio	..	..	..	12000	4300	..	..	..	..	..	..	..	16300
Total by truck	..	100	3348	14440	4702	300	..	..	..	..	..	..	22,890

By rail (carloads)

Ariz.	..	..	..	..	..	..	..	..	..	..	..	1	1
Calif.	3	1	..	..	1	4	3	3	2	2	..	2	21
La.	3	..	..	..	..	..	..	..	..	..	..	..	3
Texas	1	..	..	..	..	..	..	..	2	..	5	3	11
Total by rail	7	1	..	..	1	4	3	3	4	2	5	6	36
Total by truck (carload equivalent	..	..	1.3	5.8	1.6	.1	..	..	..	..	..	..	8.8
Total	7.0	1.0	1.3	5.8	2.6	4.1	3.0	3.0	4.0	2.0	5.0	6.0	44.8

CAULIFLOWER

By rail (carloads)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Calif.	3	1	..	..	..	1	2	9	3	3	1	8	31
Colo.	..	..	..	2	5	1	..	..	..	..	..	..	8
N. Y.	..	..	..	..	..	..	4	1	..	..	..	..	5
Ore.	..	..	..	..	..	1	..	..	..	..	..	..	1
Texas	..	..	..	..	..	..	..	..	..	1	..	..	1
Total by rail	3	1	..	2	5	3	6	10	3	4	1	8	46

CELERY

By truck (dozen bunches)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Fla.	..	..	..	..	..	..	..	..	..	..	550	..	550
Ga.	..	..	..	..	..	..	..	..	..	4	15	..	19
Mich.	..	1310	4850	5235	8865	11007	10750	7350	..	..	..	..	49,367
Ohio	..	..	..	1000	..	..	..	..	..	..	..	..	1000
Total by truck	..	1310	4850	6235	8865	11007	10750	7350	..	4	565	..	50,936

By rail (carloads)

Calif.	2	4	..	..	..	2	14	17	5	1	..	..	45
Fla.	9	..	..	..	..	..	..	..	4	10	9	11	43
Total by rail	11	4	..	..	..	2	14	17	9	11	9	11	88
Total by truck (carload equivalent)	..	.9	3.4	4.3	6.2	7.6	7.5	5.1	..	..	.4	..	35.4
Total	11.0	4.9	3.4	4.3	6.2	9.6	21.5	22.1	9.0	11.0	9.4	11.0	123.4

CHERRIES

By rail (carloads)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Mich.	..	..	..	..	..	1	..	..	..	..	..	..	1

CRANBERRIES

By rail (carloads)

Mass.	..	..	..	..	..	..	..	4	..	..	..	..	4
N. J.	..	..	..	..	..	..	..	1	1	..	..	..	2
Wis.	..	..	..	..	..	..	3	..	..	..	..	..	3
Total by rail	..	..	..	..	..	..	3	5	1	..	..	..	9

CORN

By truck (dozen ears)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ala.	..	1200	800	..	..	..	..	..	..	..	..	..	2000
Ga.	..	3250	..	..	..	..	..	..	..	..	..	..	3250

Ind.	..	75	387	2515	..	..	..	..	..	..	..	..	2977
Ky.	..	..	1000	..	..	..	..	..	..	.	..	..	1000
Tenn.	..	375	..	..	..	..	..	..	..	..	..	..	375
Total by truck	..	4900	2187	2515	..	..	..	..	..	..	..	..	9602
					By rail (carloads)								
La.	..	6	2	..	..	..	..	..	..	..	..	..	8
Texas	8	..	..	..	..	..	..	..	..	..	..	..	8
Total by rail	8	6	2	..	..	..	..	..	..	..	..	..	16
Total by truck (carload equivalent)	..	2.5	1.1	1.3	..	..	..	..	..	..	..	..	4.9
Total	8.0	8.5	3.1	1.3	..	..	..	..	..	..	..	..	20.9

CUCUMBERS

By truck (bushels)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Fla.	18	..	..	..	..	..	7	..	..	..	..	56	81
Ga.	15	820	400	..	..	..	..	..	..	..	..	..	1235
Ill.	24	..	..	..	..	77	15	10	..	..	..	..	126
Ind.	204	748	..	..	450	..	..	..	..	..	..	..	1402
Miss.	..	100	..	..	..	..	..	..	..	..	..	..	100
Ohio	..	50	..	..	..	..	..	..	..	..	.	..	50
S. C.	..	..	522	..	..	..	..	..	..	..	..	..	522
Tenn.	..	..	272	..	..	..	..	..	..	.	..	..	272
Total by truck	261	1718	1194	..	450	77	22	10	..	..	..	56	3789
Total by truck (carload equivalent)	.5	3.6	2.5	..	.9	.2	.05	.02	..	..	..	.1	7.9

GRAPEFRUIT

By truck (bags)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Fla.	..	..	..	..	..	200	..	..	99	160	170	20	649
Ga.	..	..	..	..	168	..	714	120	363	376	569	58	2.368
Total by truck	..	..	..	..	168	200	714	120	462	536	739	78	3.017

By rail (carloads)

Ariz.	.	..	..	..	..	..	..	..	..	..	..	1	1
Calif.	..	2	1	..	..	..	..	..	..	..	..	..	3
Fla.	20	2	..	..	8	16	9	9	12	8	12	11	107
Texas	..	..	..	..	..	4	10	9	8	13	21	9	74
Total by rail	20	4	1	..	8	20	19	18	20	21	33	21	185
Total by truck (carload (equivalent)	..	..	..	..	.2	.3	1.0	.2	.6	.7	1.0	.1	4.1
Total	20	4	1	..	8.2	20.3	20.0	18.2	20.6	21.7	34.0	21.1	189.1

GRAPES

By truck (baskets)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ill	148	..	608	440	..	3942	..	112	..	..	..	..	5250
Ind.	..	..	..	62	350	1197	..	..	..	..	..	..	1609
Mich.	..	..	..	450	5566	31206	..	..	..	..	..	..	37222
Ohio	..	..	..	..	479	200	..	..	..	..	..	..	679
Total by truck	148	..	608	952	6395	36545	..	112	..	..	..	..	44760

By rail (carloads)

Calif	..	..	..	8	19	26	15	7	1	..	..	..	76
Total by rail	..	..	..	8	19	26	15	7	1	..	..	..	76
Total by truck (carload (equivalent)	..	..	.2	.3	1.7	9.7	..	..	..	..	..	..	11.9
Total	..	..	.2	8.3	20.7	35.7	15	7	1	..	..	..	87.9

HONEYDEW MELONS

By rail (carloads)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ariz.	..	..	..	1	1	..	..	..	..	..	..	..	2
Calif.	..	1	17	4	..	..	..	..	..	..	..	..	22
Colo.	..	..	..	..	2	2	..	..	..	..	..	..	4
Total by rail	..	1	17	5	3	2	..	..	..	..	..	..	28

KALE

By rail (carloads)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Va.	..	..	..	..	..	..	..	2	8	14	6	..	30

LEMONS

By rail (carloads)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Calif.	9	15	11	6	3	1	2	2	4	4	5	5	97

LETTUCE

By rail (carloads)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ariz.	5	1	..	..	..	..	2	19	12	4	20	9	72
Calif.	26	20	26	21	21	19	26	12	17	20	1	1	210
Idaho	..	..	..	..	..	..	1	..	..	..	..	..	1
Wash.	..	1	..	..	..	..	..	..	..	..	..	..	1
Total by rail	31	22	26	21	21	19	29	31	29	24	21	10	284

LIMA BEANS

By truck (bushels)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Fla.	..	271	..	..	..	..	..	..	..	62	310	573	1,216
Ga.	200	720	850	..	..	..	..	..	..	..	..	..	1,770
Md.	..	..	..	500	..	..	..	..	..	..	..	..	500
Mich.	..	..	..	..	959	..	..	..	..	..	..	..	959
N. C.	..	..	1001	..	..	..	..	..	..	..	..	..	1,001
Ohio	..	..	..	160	1823	..	..	..	..	..	..	..	1,983
Va.	..	..	200	..	..	..	..	..	..	..	..	..	200
Total by truck	200	991	2051	660	2782	..	..	..	..	62	310	573	7,629
Total by truck (carloads)	3	1.7	3 4	1.1	4.6	..	..	..	..	.1	.5	1.0	12.7

MIXED GREENS

By rail (carloads)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Miss.	2	..	..	..	..	..	..	..	..	..	..	1	3

MIXED VEGETABLES

By truck (loads)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ala.	..	..	..	1	..	..	..	..	..	..	..	..	1
Fla.	2	..	..	..	..	1	2	..	7	5	16	32	65
Ga.	4	6	..	..	1	3	4	3	3	5	11	16	56
Ill.	..	2	..	..	..	..	..	1	1	..	..	..	4
Ind.	..	1	..	4	1	5	1	..	..	..	..	..	12
Ky.	1	..	1	3	..	..	..	..	..	..	..	..	5
Mich.	..	..	1	2	56	3	..	..	..	..	..	..	62
Miss.	..	3	..	..	..	..	..	..	..	..	..	..	3
N. C.	..	..	2	..	..	..	..	..	..	..	..	..	2
N. Y.	..	..	..	..	..	..	..	..	1	..	..	..	1
Ohio	42	38	50	40	45	47	52	53	42	56	56	58	579
S. C.	..	..	1	..	..	..	..	..	..	..	..	..	1
Tenn.	..	1	..	..	..	..	..	..	..	..	1	..	2
W. Va.	..	..	..	..	..	1	..	..	..	..	..	..	1
Total by truck	49	51	55	50	103	60	59	57	54	66	84	106	794

By rail (carloads)

Calif.	1	..	2	..	..	3	2	..	..	..	..	..	8
Colo.	..	..	1	..	2	2	..	..	..	..	..	..	5
Ill.	..	..	..	..	..	1	..	..	..	..	..	..	1
La.	1	..	..	..	..	..	..	..	..	..	..	2	3
Miss.	..	..	..	..	..	..	..	..	..	..	..	2	2
Texas	1	..	..	..	..	..	3	2	2	4	4	2	18
Total by rail	3	..	3	..	2	6	5	2	2	4	4	6	37
Total by truck (carload equivalent)	21.1	22.0	23.7	21.6	44.4	25.9	25.4	24.6	23.3	28.4	36.2	45.7	342.3
Total	24.1	22.0	26.7	21.6	46.4	31.9	30.4	26.6	25.3	32.4	40.2	51.7	379.3

ONIONS

By truck (50 lb. bags)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ill.	..	510	315	..	..	..	4	175	..	..	..	..	1,004
Ind.	..	..	32	228	613	1365	1369	..	186	300	160	..	4,253
Ky.	..	..	325	48	..	..	..	..	..	..	..	..	373
Mich.	..	..	..	..	85	1467	1221	480	595	665	1332	1739	7,584
Mo.	..	150	200	..	..	..	..	..	..	..	..	..	350
Ohio	..	..	..	..	388	..	..	..	..	..	..	..	388
Wis.	..	..	..	555	..	..	..	..	375	..	..	..	930
Total by truck	..	660	872	831	1086	2832	2594	655	1156	965	1492	1739	14,832

By rail (carloads)

Calif.	..	..	1	1	..	..	..	..	..	..	..	..	2
Colo.	..	..	..	..	..	2	2	..	..	..	1	..	5
Idaho	..	..	..	1	5	1	3	2	1	3	1	..	17
Ill.	..	..	..	..	..	..	..	..	..	1	..	..	1
Ind.	..	..	..	..	3	4	..	..	12	4	..	..	23
Iowa	..	..	2	..	..	..	..	..	..	..	..	..	2
Md.	..	..	..	..	..	..	..	..	..	..	1	..	1
Mich.	..	..	..	3	12	6	4	1	8	2	4	..	40
Minn.	..	..	..	2	..	3	9	..	..	5	..	..	19
Ohio	..	..	..	..	1	..	2	1	1	..	1	..	6
Ore.	..	..	..	..	..	..	..	..	1	..	..	..	1
Texas	25	10	..	..	..	..	..	..	..	..	..	10	45
Wis.	..	..	..	5	..	..	..	..	..	..	..	..	5
Wash.	..	..	1	..	..	..	..	..	..	..	..	..	1
Total by rail	25	10	4	12	21	16	20	4	23	15	8	10	168
Total by truck (carload equivalent)	..	1.3	1.7	1.7	2.2	5.7	5.2	1.3	2.5	1.9	3.0	3.5	30.0
Total	25.0	11.3	5.7	13.7	23.2	21.7	25.2	5.3	25.5	16.9	11.0	13.5	198.0

ORANGES

By truck (bags)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Fla.	..	..	..	..	..	120	..	370	1500	948	2068	921	5,927
Ga.	..	..	..	..	..	..	1141	1700	633	788	2004	870	7,136
Total by truck	..	..	..	..	..	120	1141	2070	2133	1736	4072	1791	13,063

By rail (carloads)

Ariz.	..	..	..	..	..	..	1	..	..	..	..	..	1
Calif.	11	17	18	21	19	3	..	5	..	..	..	..	94
Fla.	35	4	..	..	..	24	43	67	..	..	..	..	173
Ga.	..	..	..	..	..	..	..	..	..	2	..	..	2
Texas	1	1	..	..	..	..	..	..	..	..	..	..	2
Total by rail	47	22	18	21	19	27	44	72	..	2	..	..	272
Total by truck (carloads)	..	..	..	..	..	.3	2.9	5.2	5.3	4.3	10.2	4.5	32.7
Total	47	22	18	21	19	27.3	46.9	77.2	5.3	6.3	10.2	4.5	304.7

PEAS

By rail (carloads)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Calif.	6	4	4	..	..	..	..	..	..	..	..	..	14
Colo.	..	..	1	2	..	..	..	..	..	..	..	..	3
Miss.	5	..	..	..	..	..	..	..	..	..	..	..	5
Total by rail	11	4	5	2	..	..	..	..	..	..	..	..	24

PEACHES

By truck (bushels)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ark.	..	..	160	..	..	..	..	..	..	..	..	..	160
Ga.	..	128	922	..	..	..	..	..	..	..	..	..	1,050
Ill.	..	113	150	..	367	..	..	..	..	..	..	..	630
Ind.	..	75	485	3302	100	..	..	..	..	..	..	..	3,962
Ky.	..	479	763	12355	..	..	..	..	..	..	..	..	13,597
Mich.	..	..	240	385	11417	597	..	..	..	..	..	..	12,639
N. C.	..	..	600	..	..	..	..	..	..	..	..	..	600
Ohio	..	..	..	..	250	..	..	..	..	..	..	..	250

Tenn.	..	..	250	681	..	..	..	..	..	..	..	..	931
Total by truck	..	795	3570	16723	12134	597	..	..	..	..	..	..	33,819
By rail (carloads)													
Ark.	..	..	1	..	..	..	..	..	..	..	..	..	1
Ga.	..	4	7	..	..	..	..	..	..	..	..	..	11
Md.	..	..	..	..	1	..	..	..	..	..	..	..	1
N. C.	..	..	2	..	..	..	..	..	..	..	..	..	2
N. Y.	..	..	..	..	1	..	..	..	..	..	..	..	1
Pa.	..	..	..	1	..	..	..	..	..	..	..	..	1
Tenn.	..	..	1	..	..	..	..	..	..	..	..	..	1
W. Va.	..	..	..	..	8	..	..	..	..	..	..	..	8
Total by rail	..	4	11	1	10	..	..	..	..	..	..	..	26
Total by truck (carloads)	..	2.0	8.9	41.8	30.3	1.5	..	..	..	..	..	..	84.5
Total	..	6.0	19.9	42.8	40.3	1.5	..	..	..	..	..	..	110.5

PEARS

By truck (bushels)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ga.	..	..	290	..	..	..	..	..	..	..	..	..	290
Ind.	..	..	..	150	..	1041	..	..	..	..	..	..	1,191
Ky.	..	..	..	..	200	100	..	..	..	..	..	..	300
Mich.	..	..	..	..	..	125	440	..	..	..	..	..	565
Mo.	..	..	..	..	..	70	..	..	..	..	..	..	70
Ohio	..	..	..	..	225	..	..	..	..	..	..	..	225
Total by truck	..	..	290	150	425	1336	440	..	..	..	..	..	2,641
By rail (carloads)													
Calif.	..	1	1	7	6	..	..	..	..	..	..	..	15
N. Y.	..	..	..	..	3	..	..	..	..	..	..	..	3
Wash.	..	..	..	..	..	1	..	..	..	..	..	..	1
Total by rail	..	1	1	7	9	1	..	..	..	..	..	..	19
Total by truck (carloads)	..	..	.6	.3	.8	2.7	.9	..	..	..	..	..	5.3
Total	..	1	1.6	7.3	9.8	3.7	.9	..	..	..	..	..	24.3

PINEAPPLES
By rail (carloads)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Fla.	10	7	..	..	..	..	..	..	..	..	..	..	17
La.	1	..	..	..	..	..	..	..	..	..	..	..	1
Cuba	..	..	..	..	..	..	..	..	..	..	..	2	2
N. Y.	..	..	..	..	..	..	..	..	..	..	1	..	1
Total by rail	11	1	..	..	..	..	..	..	..	..	1	2	21

PLUMS
By rail (carloads)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Calif.	..	1	..	..	..	..	..	..	..	..	..	..	1

PRUNES
By rail (carloads)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Wash.	..	..	..	..	1	..	..	..	..	..	..	..	1

POTATOES
By truck (100 bags)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ala.	3000	842	..	..	..	..	..	..	..	..	..	..	3,842
Ga.	..	100	..	..	..	..	..	..	..	..	40	140	280
Ill.	..	..	..	..	..	780	..	..	..	..	..	..	780
Ind.	420	..	..	..	288	2717	2188	330	880	101	407	350	7,681
Ky.	..	..	5416	2985	..	..	..	..	..	..	..	..	8,401
Mich.	4863	..	..	925	5302	5481	4094	3400	4193	6102	5518	3459	43,337
Miss.	..	285	..	..	..	..	..	..	..	..	..	..	285
Mo.	..	200	200	..	..	..	..	..	..	..	..	..	400
N. C.	..	600	..	..	..	..	..	..	..	..	..	..	600
N. J.	..	..	..	300	..	..	..	..	..	..	..	..	300
Ohio	..	..	..	..	100	140	..	..	..	..	..	..	240
Tenn.	100	5141	1845	..	..	..	..	..	..	..	..	..	7,086
Wis.	..	..	..	..	..	100	..	..	..	..	..	28	128

Total by truck	8383	7168	7461	4210	5690	9218	6282	3730	5073	6203	5965	3977	73,360
						By rail	(carloads)						
Ala.	125	79	..	..	..	..	..	..	..	..	..	38	242
Calif.	2	7	3	..	..	..	..	..	..	..	..	..	12
Colo.	..	1	..	..	2	1	2	2	4	6	6	5	29
Del.	..	..	..	1	..	..	..	..	..	..	..	..	1
Fla.	..	..	..	..	..	..	..	..	2	4	13	8	27
Idaho	1	..	1	3	6	6	13	8	6	7	7	7	65
Ill.	..	..	1	..	..	..	..	..	..	1	3	2	7
Ind.	..	..	..	8	3	2	3	1	..	..	..	..	17
Kan.	..	..	2	..	..	..	..	..	..	..	..	..	2
La.	8	1	..	..	..	..	..	..	..	..	..	4	13
Me.	25	..	..	..	4	6	12	21	26	12	6	2	114
Md.	..	..	1	2	..	1	..	..	1	..	..	..	5
Mass.	1	..	..	..	..	..	..	..	..	..	..	..	1
Mich.	23	2	..	1	28	65	52	45	65	38	45	31	395
Minn.	..	..	..	..	5	18	11	4	..	9	8	7	62
Miss.	..	3	..	..	..	..	..	..	..	..	..	..	3
N. J.	..	1	..	30	49	14	2	..	..	..	..	..	96
N. Y.	..	..	..	3	1	1	1	..	1	..	..	..	7
N. C.	..	45	..	..	..	..	..	..	..	..	..	..	45
N. D.	..	..	..	..	15	9	5	5	..	3	5	3	45
Ohio	..	..	..	..	3..	..	..	..	..	..	..	..	3
Pa.	..	..	..	4	1	1	..	5	..	..	..	..	11
S. C.	1	6	..	..	..	..	..	..	..	..	..	..	7
Tenn.	..	74	26	..	..	..	..	..	..	..	..	..	100
Texas	..	..	..	..	..	..	..	..	1	7	..	..	8
Va.	..	4	2	.	..	..	..	..	..	..	..	..	6
Wash.	..	..	..	..	..	..	1	..	..	..	..	..	1
Wis.	4	..	..	7	46	11	..	..	4	9	15	13	109
Total by rail	190	223	36	59	163	135	102	91	110	89	108	127	1,433
Total by truck	23.9	20.5	21.3	12.0	16.3	26.3	17.9	10.7	14.5	17.7	17.0	11.4	209.5
Total	213.9	243.5	57.3	71.0	179.3	161.3	119.9	101.7	124.5	106.7	125.0	138.4	1,642.5

PEPPERS

By truck (hampers)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Fla.	325	70	..	..	..	..	15	..	6	55	110	5	586
Ga.	..	23	112	..	..	..	..	..	5	..	..	..	140
Ill.	..	20	20	..	..	5	25	..	..	..	..	..	70
Ind.	..	..	..	10	210	30	..	..	..	..	..	..	250
Miss.	..	128	..	..	..	..	..	..	..	..	..	..	128
Tenn.	..	..	..	45	..	..	..	..	..	..	..	..	45
Va.	..	..	415	..	..	..	..	..	..	..	..	..	415
Total by truck	325	241	547	55	210	35	40	..	11	55	110	5	1,634
Carload equivalent	.5	.4	.9	.1	.4	.1	.1	..	..	.1	.2	..	2.8

SPINACH

By rail (carloads)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Va.	1	..	..	..	..	..	..	1	..	..	..	..	2
Miss.	..	..	..	..	..	..	..	..	2	..	..	..	2
Texas	..	..	..	..	..	..	..	..	2	..	..	..	2
Total by rail	1	..	..	..	..	..	..	1	4	..	..	..	6

By truck (bushels)

Ala.	..	..	..	..	..	..	..	..	..	..	..	250	250
Ga.	..	..	..	..	..	..	..	..	..	..	..	150	150
Total by truck	..	..	..	..	..	..	..	..	..	..	..	400	400
Carload equivalent)	..	..	..	..	..	..	..	..	..	..	..	.5	.5
Total	1	..	..	..	..	..	..	1	4	..	..	.5	6.5

SWEETPOTATOES

By truck (hampers)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ala.	..	..	180	..	..	..	..	..	..	..	..	..	180
Fla.	..	..	..	..	..	..	..	..	..	..	..	350	350
Ga.	..	..	..	160	..	..	..	..	..	..	..	..	160
Ill.	30	..	..	..	450	..	..	..	..	..	..	..	480
Ind.	130	90	31	..	..	..	235	360	..	..	..	..	846

La.	..	..	..	..	..	..	..	270	..	..	..	..	270
Tenn.	1517	1204	200	1553	..	..	..	..	..	400	1100	1829	7,803
Total by truck	1677	1294	411	1713	450	..	235	630	..	400	1100	2179	10,089
By rail (carloads)													
Ala.	..	..	4	..	..	..	..	..	..	..	..	..	4
Ky.	1	..	..	..	..	..	..	..	..	..	..	..	1
La.	..	..	..	1	..	5	8	5	1	..	..	..	20
Miss.	..	..	..	1	..	..	..	..	..	..	1	1	3
N. D.	..	..	..	..	..	..	..	..	..	..	1	..	1
Tenn.	..	..	..	1	..	..	..	..	..	1	..	..	2
Total by rail	1	..	4	3	..	5	8	5	1	1	1	1	31
Total by truck (carloads)	3 0	2 4	.7	3.1	.8	..	.4	1.1	..	.7	2.0	4.0	18.2
Total	4.0	2.4	4.7	6.1	.8	5.0	8.4	6.1	1.0	1.7	4.0	5.0	49.2

STRAWBERRIES

By truck (crates)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ala.	11707	560	..	..	..	..	..	..	..	..	..	5698	18,965
Fla.	..	..	..	..	..	..	..	..	750	1491	1270	144	3,655
Ill.	322	..	..	..	..	..	..	..	..	..	..	..	322
Ind.	281	..	..	..	..	..	..	..	..	..	..	..	281
Ky.	832	68	..	..	..	..	..	..	..	..	..	63	963
La.	2878	..	..	..	..	..	..	..	..	..	..	..	2,878
Tenn.	2369	369	..	..	..	..	..	..	..	..	..	222	2,960
Total by truck	18389	997	..	..	..	..	..	..	750	1491	1270	7127	30,024
By rail (carloads)													
Ala.	..	..	..	..	..	..	..	..	..	..	..	2	2
Fla.	..	..	..	..	..	..	..	..	1	7	..	..	8
La.	17	..	..	..	..	..	..	..	..	..	5	8	30
Total by rail	17	..	..	..	..	..	..	..	1	7	5	10	40
Total by truck (carloads)	43 8	2.4	..	..	..	..	..	..	1.8	3.6	3.0	17	71.6
Total	60.8	2.4	..	..	..	..	..	..	2.8	10.6	8.0	27.0	111.6

TANGERINES

By truck (bushels)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Fla.	..	..	..	..	..	..	..	..	..	115	..	..	115
Ga.	..	..	..	..	..	..	185	335	623	296	..	..	1,439
Total by truck	..	..	..	..	..	..	185	335	623	411	..	..	1,554

By rail (carloads)

Fla.	..	..	..	..	..	..	1	10	6	1	..	..	18
Total by truck (carload equivalent)	..	..	..	..	..	..	.3	.5	1.0	.6	..	..	2.4
Total	.	..	..	..	..	..	1.3	10.5	7.0	1.6	..	..	20.4

TURNIPS

By truck (dozen bunches)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ga.	..	..	..	..	..	..	..	..	..	55	2314	..	2369
Mich.	..	..	..	..	..	..	..	..	..	33	..	..	33
Texas	..	..	..	..	..	..	..	..	..	268	..	..	268
Total by truck	..	..	..	..	..	..	..	..	..	356	2314	..	2670

By rail (carloads)

La.	..	..	..	..	..	..	..	..	1	..	..	..	1
Miss.	..	..	..	..	..	..	..	..	..	..	2	..	2
Total by rail	..	..	..	..	..	..	..	..	1	..	2	..	3
Total by truck (carload equivalent)	..	..	..	..	..	..	..	..	..	.1	.9	..	1.0
Total	..	..	..	..	..	..	..	..	1	.1	2.9	..	4.0

TOMATOES

By truck (half-bushels)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ala.	..	..	310	..	..	..	..	..	..	..	..	..	310
Fla.	871	..	..	..	..	..	..	270	250	1869	2512	4714	10,486
Ga.	266	1099	..	..	..	..	..	..	48	65	265	624	2,367
Ill.	..	..	..	..	..	884	89	490	..	..	..	..	1,463
Ind.	..	1976	1886	18	597	140	..	..	..	..	..	..	4,617
Ky.	..	..	220	60	..	..	..	..	..	..	..	..	280
La.	..	300	..	..	..	..	..	..	..	..	.	..	300
Mich.	..	..	230	..	..	1202	23	..	..	..	..		1,455
Miss.	..	1614	..	..	..	..	..	..	..	..	..	..	1,614
Mo.	..	..	540	400	..	..	..	..	..	..	..		940
Ohio	..	..	..	..	..	100	..	..	..	..	25	..	125
Tenn.	..	1430	7084	148	..	..	..	..	..	..	..	..	8,662
Texas	..	625	..	..	..	..	..	..	..	..	..	..	625
Total by truck	1137	7044	10270	626	597	2326	112	760	298	1934	2802	5338	33,244

By rail (carloads)

Calif.	..	..	..	..	..	5	9	2	..	..	..	..	16
Fla.	5	..	..	..	..	..	..	..	2	14	25	30	76
La.	..	1	..	..	..	..	..	..	..	..	..	..	1
Mexico	4	..	..	..	..	..	..	..	4	..	..	..	8
Miss.	..	29	..	..	..	..	..	..	..	..	..	..	29
Tenn.	..	7	10	..	..	..	..	..	..	..	..	..	17
Texas	27	16	1	..	..	..	..	1	..	.	..	..	45
Total by rail	36	53	11	..	..	5	9	3	6	14	25	30	192
Total by truck (carload equivalent)	1.8	11.3	16.4	1.0	1.0	3.7	.2	1.2	.5	3.1	4.5	8.5	53.2
Total	37.8	64.3	27.4	1.0	1.0	8.7	9.2	4.2	6.5	17.1	29.5	38.5	244.2

WATERMELONS

By truck (single)

State	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Ala.	..	710	1200	3940	..	..	..	..	..	..	..	..	5,850
Fla.	..	450	1605	..	..	..	..	..	..	..	..	..	2,055
Ga.	300	5912	39125	11695	..	..	..	..	..	..	..	..	57,032
Ind.	..	..	7405	151907	109847	5728	..	..	..	..	..	..	274,887
Mo.	..	..	..	3125	..	..	..	..	..	..	..	..	3,125
Tenn.	..	..	..	450	..	..	..	..	..	..	..	..	450
Total by truck	300	7072	49335	171117	109847	5728	..	..	..	..	..	..	343,399

By rail (carloads)

Ala.	..	..	11	..	..	..	..	..	..	..	..	..	11
Ark.	..	..	1	1	..	..	..	..	..	..	..	..	2
Fla.	1	8	19	..	..	..	..	..	..	..	..	..	28
Ga.	..	2	94	6	..	..	..	..	..	..	..	..	102
N. C.	..	..	1	..	..	..	..	..	..	..	..	..	1
S. C.	..	..	3	..	..	..	..	..	..	..	..	..	3
Total by rail	1	10	129	7	..	..	..	..	..	..	..	..	147
Total by truck (carload equivalent)	.3	6.4	44.9	155.6	99.9	5.2	..	..	..	..	..	..	312.3
Total	1.3	16.4	173.9	162.6	99.9	5.2	..	..	..	..	..	..	459.3

Proceedings

In commemoration of the

Fiftieth Anniversary

of the

Kentucky Agricultural Experiment Station

Wednesday, Sept. 25, 1935

PROCEEDINGS

IN COMMEMORATION OF THE

Fiftieth Anniversary

OF THE

KENTUCKY AGRICULTURAL EXPERIMENT STATION

Wednesday, September 25, 1935

LEXINGTON, KENTUCKY

BULLETIN NO. 388 NOVEMBER, 1938

THOMAS POE COOPER, Sc. D.

Director of the Kentucky Agricultural Experiment Station and Dean of the College of Agriculture, 1918—

FIFTIETH ANNIVERSARY

OF

KENTUCKY AGRICULTURAL EXPERIMENT STATION

September 25, 1935

The Kentucky Agricultural Experiment Station was established in 1885. It has for its object and mission to seek, to discern and to serve in all matters affecting the agricultural development of the State and Nation. It stands for the dissemination of knowledge to every farm home in Kentucky, to the end that agriculture may be the best as well as the greatest industry in the State. The results of its research and experimentation have been a distinctive contribution to the progress and welfare of the Commonwealth and of service nationally and internationally.

THOMAS P. COOPER,
Director.

Anniversary Committee

J. D. TURNER, *Chairman*
T. R. BRYANT
H. E. CURTIS
E. S. GOOD
A. M. PETER
GEORGE ROBERTS

PROGRAM

Wednesday, September 25, 1935

10:00 to 12:00 A. M.

Visits to Experiment Station buildings and Experiment Station farm. Members of the staff will accompany visitors.

Recess

Memorial Hall

2:00 P. M.

President Frank L. McVey, *Presiding*

Invocation, Rev. T. C. Ecton

Half A Century in Retrospect, Dean Thomas P. Cooper

As the Farmer Views the Experiment Station,
Senator Perry B. Gaines

Melville Amasa Scovell—Founder and Builder,
Professor George Roberts

Joseph Hoeing Kastle, Director 1912-1916,
Dr. G. Davis Buckner

Agriculture and Science, Dr. F. B. Mumford, Dean and Director, College of Agriculture, University of Missouri

Music

Announcements Benediction

After the invocation by Reverend T. C. Ecton, President Frank L. McVey, presiding, made appropriate introductory remarks and then introduced the speakers who presented papers as follows:—

A HALF CENTURY IN RETROSPECT

By Thomas Poe Cooper

A half century in retrospect. So stated, it sounds like a long, long time. However, the problems of existence are merely milestones in progress and a half century is not limited in terms of time but rather by accomplishments. The facts obtained by the Kentucky Agricultural Experiment Station thru its investigations, researches and regulatory work, with their far-reaching applications, form an array so imposing as to be of challenging interest. We pause to review briefly the work of the institution upon this its fiftieth anniversary.

The Experiment Station owes its existence to a resolution passed by the Executive Committee of the Board of Trustees of the Agricultural and Mechanical College of Kentucky on September 25, 1885. The establishment of the institution was without particular public acclaim or comment. Indeed, there was slight recognition of the importance or of the great implications which existed in the establishment of the institution whose primary duty was to carry on researches and investigations for the advancement of agriculture. Few recognized the significance of this event which occurred approximately a year and a half in advance of the passage of the Hatch Act, the purpose of which is "to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science."

The progress of the Kentucky Experiment Station may chronologically be divided into three periods. The first period, from establishment until about 1906, marked the struggle for existence, the attempt to chart a course of action and to win the confidence of the public. The second period began about 1906, following the passage of the feed control act, the new food and drugs act, the Adams Act, and extended to the close of the World War. These acts provided means for development and a greater expansion of the services of the Experiment Station. Further opportunity was given by the annual appropriation made by the state legislature. This was a period which

demanded greatly increased service from the Experiment Station and it focused public interest in the application of its findings to agriculture. The third period, the present one, which dates from the close of the World War, is marked by services more far-reaching than those demanded in former times. Funds provided by Congress for research permit an intensification and broadening of the basic field of scientific research and for the inclusion of the economic and social sciences as applied to basic research in agriculture.

In the selection of Dr. Melville Amasa Scovell to the directorship of the newly created institution, there were implanted, as it were, the constructive efforts, ideals and standards which have characterized the work of the Experiment Station. Dr. Scovell assumed his duties in November, 1885. One room in the basement of the present Administration building of the University was his office, chemical laboratory and general workroom.

In the winter of 1886, the legislature designated the station as the Kentucky Agricultural Experiment Station and passed an act controlling the sale of commercial fertilizers in the state, and empowered the director of the station to make all official analyses under the law and authorized him to make all necessary rules and regulations for its proper enforcement.

In the spring of '86, such tillable land as the College had was assigned to the station for field experiments. The field assigned contained about twelve acres, most of which was found to be unfit for this purpose on account of the very marked unevenness of fertility of the soil, caused by having the surface soil taken off here and there over various portions of the field for making brick for building the college.

In the same year, an Assistant Chemist was appointed. Before this, the Director was alone in the work of the station, except that by a resolution of the Executive Committee, the professors of chemistry, agriculture and botany, were to assist in the work of the station insofar as such work did not interfere with their proper college duties. After Congress passed the Hatch Act in 1887, the authorities at once took steps to put the station on a firmer basis.

Action was taken looking to the purchase of a farm for experimental purposes, for the erection of a station building for offices, laboratories, etc., and for increasing the working force of the station, but by a decision of the Comptroller of the Treasury, the funds due under the operation of the Hatch Act did not become available until the following year, and no great increase of the working force could at once be made. In June, another Assistant Chemist was employed. In the fall, a farm of 48½ acres was purchased and in May, 1888, the contract was let for the station building (which is now the law building). In June, 1888, steps were taken for the employment of an agriculturist and an assistant agriculturist, and for procuring the necessary books, apparatus, etc., which would be required as soon as the new quarters were ready.

The records show that in 1889, the officers of the institution included the director, a chemist, two assistant chemists, an agriculturist, farm superintendent, practical horticulturist, a secretary and stenographer. The early work of the station was confined almost entirely to chemical analyses, investigations and field experiments.

Three years after its organization, the Experiment Station had made studies sufficiently advanced to publish 16 bulletins covering such subjects as the effect of fertilizers on the quality of tobacco, corn fodder as a food for stock and other publications on the various aspects of fertilizers.

As early as 1892, the Experiment Station issued a bulletin which set forth the tests on marl, and the importance of lime in restoring fertility to worn lands. These tests thus set up the work in soils which has been continuous since that time.

It may be of interest to recall the small beginning of one branch of practical work on which the Experiment Station has prided itself for 43 years—that is the herd of Jersey cows and the production of pure milk of low bacterial count on a commercial scale and with no unusual equipment. This herd was established in February, 1892. The minutes of the Board of Trustees state that "The two cows now at the station and in the butter experiment are purchased from Professor Scovell at $150 each" and $816 balance on hand of experiment fund was appropriated to the establishment of a dairy.

The findings of the Station were in demand. In his early reports, Dr. Scovell indicated how the larger part of his time was taken up in answering the questions of farmers and that the requests for bulletins were such that supplies were exhausted soon after printing.

During the early 90s, it was necessary to consider methods which would provide more income. It was decided to develop certain much needed services for the farmers of the state. In the administration of acts regulatory in nature, yet primarily educational in value, it seemed proper that some portion of the fees obtained therefrom should be expended for research. This was a sound viewpoint for in the following years, the public became conscious of its need for direction in the purchase and use of products offered for human and animal consumption. As the Experiment Station developed these services, public confidence grew in the work of the institution. That its dominating purposes were to assist both the farmer and producer, to enable the rural people to come to a source from which much needed information could be obtained, and that its findings were unbiased and could not be bought became an established fact.

The second period of development began substantially in 1906. The present feedstuffs law went into effect; a new food and drug law was passed; the seed law was amended and its enforcement placed in the hands of the Director of the Experiment Station, Congress passed the bill known as the Adams Act which provided additional appropriation for research work. The passage of the national pure food law and the meat inspection law made possible cooperative work in these lines with the Government. Thus wider fields of work were entered into and the enlargement of the staff was made possible.

The twenty years which had passed had convinced many thinking, forward-looking farmers of the value of the Experiment Station and of the many ways by which agriculture could profit thru its services. There was a feeling that the state should appropriate funds for its work. This culminated in an annual appropriation of $50,000 in 1912 and gave tremendous impetus to the work of the institution. Farmers, more than ever, were interested in its findings and ready to apply the

practices which it advocated; and for the first time funds were available for the needed progress.

Perhaps the most important development under the new appropriation was the establishment of ten soil experiment fields in different parts of the state. These fields brought direct to every section of the state the work of the Experiment Station in the maintenance of soil fertility and established the basis of a better knowledge in the treatment of the varying soils of the state. Incidentally, these fields are the basis of the great soil improvement programs carried on thru the Extension Division.

The Experiment Station farm now comprised 240 acres. In 1903, the first wing of the present station building was begun and in 1905 completed; in 1913, the second wing was completed. The Experiment Station entered upon its second period of development reasonably well provided with buildings, land and equipment. The scientific staff had increased and in 1911, Dr. Joseph H. Kastle returned as head of the newly organized division of chemical research. His true conception of research gave to the institution that substantial and sound background that has contributed so much to fundamental research. His fine, eager spirit and the keen imagination which characterized his chemical and biological researches are still apparent in our laboratories.

During the third period of development, which began about 1918, increased funds made possible additional work. There was encouragement in the widening public interest and support. Additional services were assigned to the Experiment Station and its scientific work was given further impetus by the passage of the Purnell Act in 1925, with its appropriation, doubling within a few years the money heretofore made available by Congress for scientific work. Purchases of land increased the Station farm to approximately 600 acres; two substations were established, namely, the Robinson Substation in Breathitt County, with some 15,000 acres of land, which has for its chief interests the mountain problems in agriculture and forestry; and the Western Kentucky Substation at Princeton, with 600 acres of land, where the special farm problems of western Kentucky are given particular study. The physical plant of the Experiment Station at Lexington was expanded by

the erection of the livestock pavilion, the dairy products building, the agricultural engineering building, the small animal house, beef cattle, hog and sheep barns and poultry plant. The staff has increased until now its scientific workers and clerical staff number 100.

Outstanding Achievements

Kentucky may take a pardonable pride in the achievements of the Agricultural Experiment Station. Much of its work is original. It has established agricultural principles of great value not only for Kentucky, but nationally and internationally. Interesting as these accomplishments are, time will permit merely the mention of those of marked importance.

A service which effects an annual saving of thousands of dollars to the state as well as to the Nation was the discovery and isolation of the germ causing infectious abortion in mares. The disease made its appearance in 1893 and became so widely distributed that it threatened the horse industry. In 1911, research workers at this institution isolated the germ and four years later perfected a vaccine, now widely used, which immunizes mares against the disease.

Discoveries of the causes of sterility in brood mares and of the diseases of new-born foals, and the advocacy of breeding hygiene in the prevention of these troubles made the Experiment Station invaluable to the horse industry of the state and brought it international fame.

The results of investigations as to the cause of forage poisoning in horses, cattle and mules (known in humans as botulinus) have meant much economically to the livestock producers of the whole country. After an extended study, an anaerobic germ was isolated from the digestive tracts of horses dead from the disease, which when grown in pure culture and injected into other animals produced the disease. The same germ was also isolated from feeds causing forage poisoning and further studies resulted in the production of a preventive serum.

Of importance is the classification of a type A animal strain of hemolytic streptococci, the organisms of the para-

typhoid group, particularly aertrycke. Other research work in animal nutrition and diseases determined the trouble in sheep commonly called pregnancy disease or acidosis and found the preventive to be a balanced ration.

Scientists at the Kentucky Experiment Station were among the first to establish the fact that milk fever in cows is a biochemical problem due to physiological unbalance.

Studies of the cause of clover bloat, pellagra, the effect of lysine content of feeds in the growth of chicks, the cause of rancidity in corn meal, are but a few of the important investigations which resulted in new and valuable information to the world.

Intensive studies of tobacco diseases have been conducted with the object of finding simple, easily applied preventive measures for the common diseases of Kentucky's chief cash crop. The principal sources of infection with mosaic disease, commonly known as walloon or blue or black french, have been discovered. This disease was regarded as a serious menace to the tobacco industry for more than fifty years. Workers at the Kentucky Experiment Station first found that the principal source of infection was natural leaf tobacco chewed or smoked by workers while weeding and pulling tobacco plants. This method of controlling mosaic has been tested in many parts of the world and is gradually becoming a standard practice in tobacco-producing areas. Not only is the information of value to tobacco growers, but it is of equal importance to tomato growers, who find that frequently mosaic enters greenhouse tomatoes from tobacco used by the employees.

Other virus diseases of tobacco have been studied with results of scientific importance. The common mosaic disease of potatoes was found to be caused by a mixture of two viruses, one of which is readily transmitted to tobacco grown in the vicinity of potatoes. Cucumber mosaic and certain other virus diseases of tobacco were found to be transmissible to potatoes. Thus a further relation between the virus diseases of these two important crops was established.

In continuous progress are studies of the life history of various insects and fungi injurious to plants, and the develop-

ment of means of checking their injury by spraying or otherwise to prevent enormous losses which they occasion.

In 1930, as a result of hybridizing resistant varieties of dark tobacco with Burley, Kentucky White Burley No. 5, a highly root-rot resistant strain of tobacco was introduced. More than three-fourths of the tobacco grown in many counties is of this variety. Extensive breeding experiments have been under way for some time to develop varieties of dark tobacco resistant to root rot. Resistant strains of the Green River type have been tested by farmers and have proved satisfactory. Dark-fired resistant varieties are soon to be introduced.

Another important contribution is the solution of the problem of red clover failure which became serious on Kentucky farms about 1930.

The Experiment Station has developed varieties of wheat, Ashland and Kentucky, much superior to those previously grown in the state; new varieties of oats and barley especially adapted to Kentucky. It was among the first to test Korean and Kobe lespedeza and to recognize their possible value.

Previous to 1912, it was thought that only ten of the ninety or more chemical elements then known were essential in the economy of both plants and animals. It was well known among agricultural chemists that as many as twenty-five or thirty additional chemical elements could be detected in small quantities in the tissues and organs of both plants and animals which received their sustenance from fertile soils in a normal way. A study to ascertain the necessity and function of a number of the minor chemical elements in the economy of plants and animals was begun in 1912. This was the first attempt on the part of an experiment station to obtain conclusive evidence that more than ten of the chemical elements are necessary factors, in the economy of both plants and animals. Several years of extensive researches in nutritional problems of both plants and animals at the Kentucky Experiment Station show that a number of the minor chemical elements, including manganese, copper, zinc, boron and iodine are factors of fundamental importance for the normal growth and metabolism of both plants and animals. Formerly, it was assumed that the soils contained an adequate supply of minor chemical elements and that the important food crops

grown on any soil would be able to extract from it all the minor elements necessary not only for crop growth but also for the growth and proper functioning of animals when the plant products were consumed as food. It is shown that this assumption is erroneous in many instances and that some soils are not only deficient in the major elements, nitrogen, phosphorus, calcium, magnesium and potassium but also are deficient as well in the minor elements, maganese, copper, zinc, boron and iodine; consequently they produce no crop at all, or poor quality of important foods, inadequately supplied with the mineral nutrients necessary for the normal metabolism of domestic animals and man.

The establishment of the various soil fields and much laboratory work on soils have furnished a basis for a comprehensive soil improvement and conservation program, applicable to the various soil areas of the state. It has been shown that practically all soils of the state may be brought to a high state of productivity by the simple process of applying lime and phosphate and the proper use of legumes—a condition that puts Kentucky in a highly favorable position because of her abundant supply of cheap liming materials, proximity to the phosphate fields and favorable climate for grasses and legumes.

Numerous trials and investigations have been made in the field of animal feeding and much of the information obtained is being utilized by the farmer and feeder.

Research in economics and rural life has been stressed and the results obtained from these studies bear no small part in the betterment of life within the state.

Representative herds of purebred beef cattle, dairy cattle and hogs, as well as flocks of purebred sheep and poultry are maintained by the Experiment Station at Lexington and at its substations.

Briefly, these are a few of the many accomplishments of the Kentucky Agricultural Experiment Station within the past half century and a short portrayal of the development of the institution. The establishment of the Experiment Station was due to the foresight of men who were confronted with agricultural problems of their day. Since that time the progress of the Experiment Station is marked by the exigencies of our

times. As conditions become more complex, the demands on the Experiment Station become more urgent. The problem of adequately financing agricultural projects has often been puzzling, but the gratitude and appreciation of the people of the state and the recognition nationally and internationally is indeed heartening.

The history of an institution depends intimately upon its staff. From the beginning the Kentucky Agricultural Experiment Station has been successful in procuring men and women imbued with ideals of research and service. They have performed their work well and many have attained national and international reputation. We are fortunate to have with us today, three members whose service almost parallels the existence of the institution—Dr. Alfred M. Peter, Mr. Henry E. Curtis and Dr. Harrison Garman.

Thruout the half century the Experiment Station has had the confidence and support of the leading farmers, the cooperation and good will of business organizations, the efforts of the legislature to provide funds to meet its necessities. It constantly strives to seek, to discern and to serve in all matters affecting the agricultural development of the State and Nation. It stands for the dissemination of knowledge to every farm home in Kentucky to the end that agriculture may be the best as well as the greatest industry in the State. The results of the research and experimentation of the Kentucky Agricultural Experiment Station have been a distinctive contribution to the progress and welfare of the Commonwealth and of service nationally and internationally.

MELVILLE AMASA SCOVELL, FOUNDER AND BUILDER

By George Roberts

Melville Amasa Scovell, the first Director of the Kentucky Agricultural Experiment Station, was born at Belvidere, New Jersey, February 26, 1855, and died at Lexington, Kentucky, August 15, 1912, in his fifty-eighth year and the twenty-seventh of his directorship. Shortly after his birth his family moved to Chicago, and from there to a farm in Champaign County, Illinois, the county in which the University of Illinois is located. He graduated from high school at the age of fifteen, and entered the University of Illinois at the age of sixteen. He specialized in chemistry, graduating at the age of twenty, and two years later earned the Master of Science degree. In his sophomore year at the University he was appointed assistant in chemistry, and after graduation he was appointed instructor in chemistry, serving in this position for one year. He had charge of a chemical exhibit at the Centennial Exposition at Philadelphia in 1876. He served as private secretary to the Regent of the University from 1876 to 1879. He was appointed Instructor in Agricultural Chemistry in 1878, Assistant Professor in 1879, and Professor in 1880, at the age of twenty-five, being the first to hold this professorship at the University of Illinois. His rapid promotion in his professional field, with attendant responsibilities, was the fulfillment of his youthful promise of ability.

While serving on the staff of the University of Illinois, Professor Scovell became interested in the manufacture of glucose and of sirup and sugar from sorghum and other sugar-producing plants, and in association with Dr. H. A. Weber patented a number of processes for clarifying juice from sugar-producing plants and for the manufacture of products from sorghum. In 1883-84 he was superintendent of the Kansas Sugar Works, a commercial plant at Sterling, Kansas. In 1884-85 he was special agent for the United States Department of Agriculture, having charge of certain phases of sugar production from sorghum and sugar cane in Kansas and Louisiana

In May, 1885, the United States Commissioner of Agriculture, Mr. Norman J. Coleman, issued a call to the various agri-

MELVILLE AMASA SCOVELL, Ph D.

Director of the Kentucky Agricultural Experiment Station, 1885–1912.

cultural colleges and other industrial and educational institutions, inviting them to send representatives to meet in convention in Washington. President Patterson of the A. & M. College of Kentucky attended this meeting and said concerning its deliberations:

> "The subject which came in for the largest share of discussion, the one in which I was most interested, was that of the establishment of experiment stations. Some such stations were then operative in a number of states and were rendering great service to the farmers. I saw a distinct opportunity in the intelligent work of an experiment station in Kentucky, and immediately upon my return made plans looking toward its establishment. I was persuaded that not only would the State be benefited by an experiment station, but that the relations of the College to the farmer would be greatly improved thereby.'

This last sentence of President Patterson's statement has been amply justified by fifty years of subsequent history; but had not a man of tact, ability, and singleness of purpose to render the best service possible to the farmers of the State been chosen as first Director of the Experiment Station, the story might have been very different. In my opinion the attitude of open hostility toward the A. & M. College that existed on the part of many people of the State, and of indifference on the part of many others, were turned into one of appreciation and friendliness more by the service of the Experiment Station than by any other influence.

The Agricultural and Mechanical College of Kentucky was founded in 1865. Twenty years had passed without very much substantial instruction in agriculture, for there was not a body of scientific knowledge sufficient for such instruction, here or elsewhere. It was not until experiment stations, thru their research, developed reliable scientific information that could be used for instruction that agricultural colleges began to attract large numbers of students. This development brought the land-grant institutions into prominence, strengthened other departments and gained support for them as much as for the agricultural departments themselves.

In the autumn after the meeting in Washington, President Patterson visited the Universities of Wisconsin, Michigan, and Illinois, observing their work and seeking a director for the Station in Kentucky. Shortly after his return the Executive Committee of the Board of Trustees met, on September 25, 1885, and

passed a resolution establishing the Agricultural Experiment Station. At this meeting, upon the President's recommendation, Prof. M. A. Scovell was elected to the directorship of the Station at a salary of fifteen hundred dollars per year. The services of Dr. Robert Peter and Prof. A. E. Menke, chemists, and Prof. A. R. Crandall, geologist and botanist, members of the teaching staff of the College, were placed at the disposal of the new Director. Thus the founding of the Experiment Station antedated the passage (in March, 1887) of the Hatch Act extending Federal aid to experiment stations.

Professor Scovell arrived in Lexington on Thanksgiving Day, 1885, to begin his duties as Director. A single room in the basement of the present Administration Building (then called the College Building) was fitted up as office and laboratory. (Here is a hint to some young men who think they cannot do anything without a lot of fine equipment to start with.) His was an example of that faith and courage that remove mountains. Before him was a task to challenge his imagination and all his resources. The immediate success or failure of the station was his success or failure. He it was who would have to determine policies, select personnel, meet farmers and convince them that scientific investigation held possibilities for improving their lot—in short, to create a friendly attitude toward the new institution. He knew that the future lay only in one course, that of immediate service to agriculture that could readily be utilized and appreciated by the average farmer of the State. I say that he knew this, because it was the guiding motive of his work in the beginning, and those of us who were intimately associated with him know that it was his guiding motive to the end of his career. He did not, could not, from his very nature, sacrifice ideals of public service for immediate advantage thru political maneuvering, which he despised and which always is dearly paid for sooner or later. While he had the highest regard for and encouraged what some call pure research—that is, research that does not have as its direct object the solution of some immediate problem of economic importance—he made the solution of farmers' problems his first concern.

The Legislature of 1886, thru the initiative of Professor Scovell, passed an act regulating the sale of commercial ferti-

lizers, which placed the administration of the law in the Director of the Experiment Station. In this act the Legislature, in specific language, designated the newly organized experiment station as the "Kentucky Agricultural Experiment Station." This act required that each bag or other package of fertilizer offered for sale carry a label bearing a statement of the analysis certified by the manufacturer to the Director of the Experiment Station. There was at the time of the passage of this act a law regulating the sale of fertilizers, but it was not effective. It was Professor Scovell's alertness to the welfare of the farmer, as illustrated in his immediate sponsoring of this law, that first won for him and the Experiment Station the confidence of the farming public that never abated thruout the twenty-seven years of his director-ship, the longest then on record.

Very soon after entering upon his duties, Doctor Scovell made plans for experimental work on soils and crops. Such tillable land as there was on the campus of 52 acres was assigned to him. In 1886 he made tests of varieties of potatoes, of methods of seed-bed preparation, and of the effect of fertilizers on yield. He made a similar test on wheat seeded that year. Another test of interest and significance that he and his associates made at the time (1887) was a study of the composition of nitrogen-fertilized bluegrass and unfertilized bluegrass, both cut at different stages of growth. He found a range in protein content from nearly 18 percent for fertilized bluegrass cut May 13, down to 9 percent for unfertilized grass cut June 9. He found similar differences in other grasses. In this is a lesson that is yet to be learned by a large majority of our farmers, namely, that by making soil fertile, not only may larger yields be more economically produced, but the nutritive value of pasture and other crops may be greatly increased; and, by inference, that pastures are more nutritious if grazed at the proper stage of growth than if allowed to become too carbonaceous.

Doctor Scovell saw the great need of immediately obtaining land for experimental purposes, and in October, 1887, purchased the first unit of the present Experiment Station farm, a tract of 48 acres, on which is located the Director's residence. By 1891 he had many field experiments under way on the newly acquired farm. They included variety tests of various crops, methods of

seeding and cultivation, and fertilizer tests. He made additions to the farm until at his death it consisted of 240 acres. He had visions of more additions and used to wave his hand to the south and say, "We will own that land some day." Dean Cooper, with his usual foresight and good judgment, has, upon his own initiative, made Doctor Scovell's dream a reality; the central farm now contains approximately 600 acres.

While on the subject of land, it should be stated that Doctor Scovell at once recognized that results of soil experiments conducted on the farm at Lexington must necessarily have limited application to other soils of the State, because of the wide difference in the nature of the soils. Unable to purchase land elsewhere for experimental purposes, he conducted cooperative fertilizer tests with farmers in different parts of the State. In 1890 Doctor Scovell had in various parts of the State, from Taylor County to Fulton County, more than a dozen such cooperative experiments. Not only was he recognizing the diverse nature of the soils of the State, but he was making the acquaintance of farmers and stimulating their interest in the new institution.

Doctor Scovell, of course, knew that cooperative experiments could never be conducted with the accuracy and for the length of time necessary for reliable conclusions. Nor was there money for purchasing land in various parts of the State. This situation came to a head in 1912 when a proposal was made by an interested member of the Legislature to introduce a bill to establish a sub-experiment station in western Kentucky. Professor Scovell was at the same time interested in obtaining an appropriation for generally strengthening the work of the Experiment Station. Because of his earnestness, sincerity, and his reputation for seeking only what was for the best interests of the State, he was able to get passed a combination bill appropriating $50,000 annually for various lines of research, among which was a provision for the establishment of soil experiment fields in various parts of the State, instead of an appropriation for a substation which could serve only one region. Doctor Scovell was not opposed to substations, but knew that with the amount of money the Legislature was likely to appropriate much more good could be accomplished by a number of small experiment fields than by a substation. Under that provision, nine experiment

fields have been established in different parts of the State. Because of the interest in soil improvement that had been developed by the Experiment Station, and because of the confidence of farmers in the Experiment Station, that had been developed by Doctor Scovell, the Experiment Station did not have to buy land for any of the experiment fields, it being provided by local people, usually by the county fiscal court.

The work on these experiment fields raised many questions which could not be answered on their limited area, and made logical the establishment of substations, which were soon developed under Dean Cooper's administration.

I have used the phase of work with which I am most familiar to illustrate the vision and constructive genius of Doctor Scovell in accomplishing results. But Doctor Scovell undertook to develop all the important phases of agricultural research.

The erection of an Experiment Station Building (now the Law Building) was begun in 1888 and finished early in 1889. The staff of 1889 consisted of the Director; A. M. Peter and H. E. Curtis, assistant chemists; Harrison Garman, entomologist and botanist; and an assistant each in horticulture and agriculture. In 1892 a department of horticulture was organized, with C. W. Mathews as its head. Mr. Curtis is yet in active service, with forty-eight years to his credit, perhaps the longest record of experiment station service in the country. Doctor Peter and Doctor Garman are both quite active on the emeritus list.

As early as 1889 experiments were begun in animal feeding, tests being made with pigs, and the next year with sheep. But Doctor Scovell was best known in the field of animal production for his work with dairy cattle. He was recognized as one of the outstanding dairy experts in this country, particularly as a judge of dairy cattle. The Breeders Gazette spoke of him as the best known and best liked judge of dairy cattle in America. He judged dairy cattle frequently at state fairs in Indiana, Ohio, Illinois, Tennessee and Texas, and at the Pan-American Exposition at Buffalo, the National Dairy Show, and the Canadian National Dairy Show at Toronto. He early began the development of a Jersey dairy herd at the Kentucky Experiment Station which has continued to the present as an outstanding herd,

thru additions and improvement by breeding. There are descendants in the herd today of Dolly's Valentine, added to the herd in 1898. She held the world's record for butterfat production from 1899 to 1905. As an indication of the kind of dairy that had been built up under the guidance of Doctor Scovell, we cite the fact that in 1915 milk from it shipped to the San Francisco Exposition won second prize, with a bacterial count of 300 on arrival; the first prize went to California milk. In February, 1893, Doctor Scovell was appointed chairman of a committee to conduct a series of dairy tests at the World's Columbian Exposition. This committee was composed of such men as Babcock, of Wisconsin, of butterfat test fame; Armsby, of Pennsylvania, expert in animal nutrition investigations; and representatives of various dairy cattle organizations. The committee met daily for ninety days, during which the tests were in progress. The data obtained covered nine hundred pages, a resume of which was published by Doctor Scovell in the Jersey Bulletin. In connection with this work, Doctor Scovell invented a milk sampling tube which was described as a useful instrument which would take an accurate small sample of milk from a cylindrical bucket. The Experiment Station dairy has been a powerful influence in establishing pure milk supplies for Kentucky towns and cities.

Doctor Scovell was trained as a chemist and always retained his interest in this field. As Director of the Station, he was a member of the Association of Official Agricultural Chemists, and served on important committees, both executive and technical, and was president in 1889-90. He was active in promoting the enactment of pure food and drug legislation, having served on the Committee on Pure Food Standards with Wiley, Jenkins, Weber and Frear, names of national prominence in those days.

In addition to all this work on committees, Doctor Scovell found time to do research work. He worked out a modification of the Kjeldahl method of determining nitrogen to include nitrates, a piece of work which attracted universal attention and was adopted as an official method by the Association of Official Agricultural Chemists. The degree of Doctor of Phil-

osophy was conferred upon him in 1908 by the University of Illinois, this piece of work being his thesis.

Doctor Scovell was active in the Association of Agricultural Colleges and Experiment Stations, having served as secretary-treasurer in 1891, later as vice president, and finally as president in 1909, a testimony to his prominence as a national agricultural leader. He was for eleven years a member of its Executive Committee, a tribute to his executive ability and to the esteem in which he was held.

It is no wonder that as a young man with a growing record of accomplishments, other institutions sought his services. He was offered the directorship of the Illinois Agricultural Experiment Station in 1894, but declined.

In 1908 the Legislature gave the A. & M. College the status of State University, with the usual university organization consisting of colleges. In 1910 Doctor Scovell was made Dean of the College of Agriculture, retaining the directorship of the Experiment Station. He was thus able at once to reorganize the College, coordinating all the various teaching, research and extension activities, to which had been recently added a department of home economics. Within the two remaining years of his life the extension work of the College, with T. R. Bryant in charge, had so developed that it was having a great influence in many localities in the State. We are accustomed to think of extension work as a development under the Federal Smith-Lever Act of 1914, but the work in Kentucky was well under way before that law was enacted.

At the time of the death of Doctor Scovell an addition to the Experiment Station Building was under construction and the staff numbered between fifty and sixty, practically every phase of agricultural investigation being represented.

I think safely it may be said that Doctor Scovell overtaxed his physical strength in service to a cause and to a people, both dearer to him than his own personal interests.

An estimate of Doctor Scovell's career would not be complete without a tribute to his devoted wife, Mrs. Nancy Davis Scovell, who was always keenly interested in all the affairs of the Institution and who, by her gracious personality, helped to

form that strong bond of friendship that so characterized his relationship with the local community and the State.

Doctor Scovell was more than scientist and executive. He had time to be interested in all things that made for a better community—large or small. He was neighborly and took time to show it. He had a saving sense of humor, without which it is difficult to be a great executive. The resolutions of the staff upon his death recited his merits as a director and then stated: "but more than all these (he was) the gentle, kindly, sympathetic friend." The resolutions of the American Association of Agricultural Colleges and Experiment Stations contain these statements: "He was a public spirited citizen, mindful of the obligations of good citizenship, and a helper in the affairs of neighborhood and state." . . . "The members of this association desire to express their grateful recollection of a life spent in earnest public services and of a friend courteous, loyal, broad in sympathy and unspotted from the world." Dr. Joseph H. Kastle, an associate thruout most of his career in Kentucky, said that in all this time he did not recall seeing him angry nor remember to have heard a single harsh or unkind word fall from his lips, nor an unkindly criticism of his fellow man. He quoted as applicable to him the proverb "He that is slow to anger is better than the mighty; and he that ruleth his spirit than he that taketh a city." Upon his death, many letters and telegrams of condolence and sympathy came from all parts of the United States and from Canada, attesting the high esteem in which he was held. At the hour of his funeral traffic in Lexington was stopped for a brief period, an impressive token of the high respect in which he was held by the people of this city.

Fortunate indeed was Kentucky in having such a man as the first director of the Experiment Station to lay the foundation for so important an institution as the Agricultural College has become with its manifold activities in research, teaching, and extension work.

Very appropriately we may apply to Doctor Scovell the following from Ruskin's "The Lamp of Memory": "When we build, let us think we build forever. * * * Let it not be

for present delight, nor for present use alone; let it be such work as our descendants will thank us for; and let us think, as we lay stone on stone, that a time is to come * * * when men will say as they look upon the labor and wrought substance of them, 'See this our fathers did for us.' "

JOSEPH HOEING KASTLE, Ph. D.

Director of the Kentucky Agricultural Experiment Station, 1912–1916.

JOSEPH HOEING KASTLE, Director, 1912-1916

By G. Davis Buckner

Dr. Joseph Hoeing Kastle returned to his native and dearly loved state of Kentucky, July 1, 1911, to become Head of the newly created Department of Chemical Research in the Kentucky Agricultural Experiment Station. He was indeed wisely chosen for this position because of the complexity of his interesting character, lovable nature, excellent education and varied training. Joseph Hoeing Kastle excelled as a teacher, scientist, naturalist, philosopher, humanitarian and friend.

On September 20, 1912, Dr. Kastle became Director of the Kentucky Agricultural Experiment Station. This position he held at the time of his death, September 24, 1916.

Due to increased state and federal appropriations, the four-year period of his directorship was marked by great expansion in all departments. Particularly rapid were the growth of the agricultural extension program, the increase in physical equipment of the Experiment Station and the expansion of research in practically every field of agriculture.

The complex duties and responsibilities brought about by enlarged activities were borne fearlessly, conscientiously and effectively by this man whose physical make-up had been impaired from early childhood and whose nature was fundamentally that of a teacher and scientific investigator. His burden was made lighter because of the helpful cooperation of many of the Station staff.

The brilliant mind and magnetic personality of Dr. Kastle stimulated many lines of scientific research at the Experiment Station, the influence of which has continued and will continue thru the years. He infused his associates with eager desire to investigate the unknown; his personal energy and industry were examples for endless labor, and his standards of honesty, courage and kindness were of the highest order. He was an unsually gifted speaker and as such was greatly in demand.

That he attempted to live up to his standards and ideals was well shown when, shortly before his death, he said to a group of farmers, "In all our dealings with the farming public

we have sought to make friends for the institution we represent but above all we have sought to render service—the most scientific and efficient service—to the great people of our commonwealth''

When we that knew him have passed on, the name of Joseph Hoeing Kastle will lose its magnetic charm and will be spoken less frequently, but his work and influence will remain. Those who came in contact with this man were inspired, made to feel a glow of warmth and kindliness and were lifted above the ordinary. No higher tribute can we pay to the memory of Joseph Hoeing Kastle than to say that he carries thru eternity the respect of the scientific world, the friendship of his associates, the love of his students and the gratitude of their parents.

AS THE FARMER VIEWS THE EXPERIMENT STATION

By Perry B. Gaines

At first, I hesitated to accept the kind invitation to participate in this program because I realized my limitations as a public speaker and felt reluctant to assume the responsibility of making an address upon so important an occasion as this. After thinking it over I wondered if the sincerity of my utterances concerning this particular subject would not, in a measure, compensate for my lack of oratorical attainment and that, after all, some of you might not be more interested in hearing in plain language, simply spoken by an average farmer, how the average farmer views this experiment station than to hear a pleasing eulogy of it delivered by some gifted orator not in as close touch and sympathy with the masses who go to make up our farming group.

Having been born and reared in the country, having chosen farming as my life vocation and given, at all times, my personal attention to the details of management and operation of my lands I have been confronted with much the same conditions—much the same problems—as the average farmer and think it fair to assume that my personal views and my personal opinion of the Station should reflect with reasonable accuracy the views and opinions of tens of thousands of other Kentuckians now engaged in the pursuit of agriculture.

In giving expression to those views I shall undertake to be both frank and conservative, and restrain as far as possible any sentimental enthusiasm to which I might be inclined because of my high personal regard and warm personal affection for members of the University and the Station staffs. However, in the light of a most superficial knowledge of facts pertaining to the practical services rendered and fine influences wielded for the betterment of our agricultural, economic and social lives by the Experiment Station, it is hard for one to voice his appraisal of its true value and not appear a bit overenthusiastic and extravagant in his language.

The development of the Experiment Station from its modest beginning a half century ago to its present high place in the sun has been one of constant, sure and substantial prog-

ress and it presents a splendid illustration of what may be accomplished by intelligent, well directed, persistent effort. Frankness compels me to admit, tho, that it has not always enjoyed the same high esteem and confidence of the public it holds now. Like every other progressive movement, it was compelled to win its way thru a maze of skepticism, disapproval and, in some instances, opposition. Those of you familiar with its earlier history will recall that at that time the farmers, as a class, looked upon both the Station and the College of Agriculture with doubt and misgivings as to their practical value.

Endowed as they were with a heritage of land possessing much of its virgin fertility and endowed also with a spirit of independence and self-reliance inherited from their pioneer ancestry, our Kentucky farmers could not easily bring themselves to believe that any college professor or college student could know more about farm management then they themselves knew—that the theoretical knowledge and teachings of those men could compare with the practical knowledge they had gained from their own experiences or from the experiences of their fathers, grandfathers or neighbors who had been successful, as success was generally rated—men who likewise scoffed at and doubted the practical worth of a lot of "book learning" applied to farming.

Even up to the time of the establishment of the Extension Service, some twenty years ago, when agricultural agents were offered to counties willing to cooperate by the subscription of nominal sums toward the payment of their salaries, there existed instances of almost open rebellion against the suggestion. The idea, they reasoned, of sending young upstarts like those to teach us how to run our business. Why, they don't know whether corn should be planted in the dark of the moon or in the light of the moon. They don't know whether the pigs, the calves and the colts should be castrated and weaned when the sign of the zodiac is in the head, in the heel or in the heart. They couldn't tell by looking at a sick cow whether or not she had the "hollow horn", the "hollow tail" or had "lost her cud." That if they did know what was the matter with her they wouldn't know how to doctor her. If she had the "hollow horn" they wouldn't know how to bore holes

in horns to relieve her. If she had the "hollow tail" they wouldn't know how long a slit to make in her tail, where to make it or how much salt to put in it to cure that and if she had lost her cud they would not have the least idea how to make and give her another one of those important morsels. Why, one of those fellows even had the presumption to offer to tell Aunt Martha how to raise chickens, just as tho she hadn't been raising chickens for more than forty years and hadn't cured them of the cholera by putting red oak bark in their drinking water and hadn't cured them of the gapes by twisting the worms from their throats with bluegrass straws long, long before the young college sap was born. Now, while you will doubtless accept those things as having been spoken in a spirit of levity, I say to you in all seriousness that such outbursts of resentment and disgust were not so unusual as you may be inclined to believe.

Such an attitude toward the Station and especially toward its Extension Service was not confined wholly to the hard headed farmers either. Many other good citizens looked upon the project as a lot of theoretical tomfoolery gotten up to give "white collared professors" and "college boys" jobs—just another waste of the taxpayer's money, they argued.

But under capable teaching and intelligent direction on the part of the Station staff together with the sane diplomacy, ability, courage and energy shown by those young county agents, such prejudices were finally and forever dissipated and, today, the service rendered by the Experiment Station thru its various branches is generally considered to be one of the most valuable, one of the most indispensable, yet made directly available to all the citizens of Kentucky.

I say directly available to all the citizens advisedly, because that is literally true. There is hardly a business, vocation or profession which does not receive helpful cooperation and aid from some branch of the station's activities. The so-called agricultural agents are now looked upon as being much more than their title implies. Generally speaking, they are considered among the leading and best informed citizens of their respective counties and their counsel and advice is freely sought and given upon non-agricultural as well as agricultural matters.

But of course the paramount and most important function of the Station is, as it should be, directed to the advancement of agriculture and whether in the role of cooperating with and administering the AAA program or in giving lessons and demonstrations in domestic science to the housewives, its forces are always on the job and do that job cheerfully and well.

When it is considered that the prosperity of the farmer is essentially the yardstick with which any lasting prosperity of our country must be determined, when it is considered that in the ideals of the farm home lies the greatest strength—the greatest influence toward the building and maintenance of a more prosperous, contented and forceful citizenship—and that whatever is done toward the advancement of agriculture and the strengthening of the farmer's social and economic condition is immediately reflected in our state and national structures, the real and the potential value of an institution dedicated to the task of promoting and aiding such a cause can not be easily computed.

No vocation offers a better opportunity for man to live a broad, interesting and happy life than does the pursuit of agriculture, and since by the acquisition of knowledge and its intelligent application he is enabled to make his lands produce more bounteous crops, is enabled to breed and to feed better livestock, is enabled to provide for himself and his family the comforts and conveniences of a home where his children may be reared in its clean wholesome environment, too much consideration and too much effort can not be given to making that knowledge available to him and to inspiring him with the ambition to apply it in the art of uplifting and dignifying his occupation and of making his community and his state a better place in which to live.

That very thing is being done for him by his Experiment Station. That institution, thru its research and experimental work, has acquired and continues to acquire a wealth of sound and useful knowledge and thru its extension service, by radio, by publication and other means is disseminating that knowledge so thoroly and so effectively that there no longer remains an excuse for a Kentucky farmer to be ignorant of the basic prin-

ciples of advanced agriculture even tho he may have been denied the semblance of a common school education.

Yes, the value to the farmer of such an institution thru its extensive and diversified work is, indeed, hard to estimate. It goes so much farther than helping him to make greater commercial dividends upon his investment, it goes so much farther than teaching him the fundamental principles of his business, it imbues him with a greater respect and a greater love for his chosen vocation, it instils within him a keener appreciation of his good fortune in being in league and in partnership with nature and of his dealings with growing and living things the charm and fascination of which can not be equaled in any other occupation in the whole wide world.

SCIENCE AND AGRICULTURE

By F. B. Mumford

The celebration of fifty years of service to agriculture by an institution of such eminence as the Kentucky Agricultural Experiment Station is an event of national interest and one for congratulation on the part of similar institutions located in forty-eight States of the United States and the outlying territories and dependencies.

The Kentucky Agricultural Experiment Station was organized before the passage of the Hatch Act by the Federal Congress in 1887, thus placing it among that enterprising group of States which early recognized the importance of science as related to the agricultural industry. The passage of the Morrill Act in 1862, providing for colleges of agriculture and mechanic arts, had resulted in the establishment of a large number of institutions attempting to teach the subject of agriculture to students in a regular college curriculum. We can not say that these colleges were successful in their early efforts. They were not satisfactory to the farmers for whom they were organized and were held in low esteem by the faculties of the older institutions.

We are able now to determine the reasons for these early failures. The teaching of agriculture before 1885 or 1890 was either in the nature of empirical knowledge based on actual farm experience or the teaching of principles, chiefly chemical, by scientists who had no adequate knowledge of agriculture.

There was yet to be developed a body of knowledge by the agricultural experiment stations which was to constitute the basis for all agricultural teaching including not only college teaching but agricultural extension teaching as well. At the present time improved agricultural practices are based on the sound foundation of scientific research. I think the agricultural experiment station is unique among scientific institutions in that it has not only discovered principles underlying the agricultural industry but it has very definitely developed a technique for the application of the discoveries of science to the varied requirements of the farm enterprise. The progressive development of the colleges of agriculture, both in resident

teaching and in agricultural extension, has been made possible by research in agricultural experiment stations. From the passage of the Hatch Act in 1887 to the present the history of these institutions has been a history of continual progress, of increasing importance to agriculture, and a more or less reluctant acceptance on the part of established institutions for higher education.

It is evident, from the provisions of the Federal and State legislation providing for the establishment and further development of agricultural experiment stations, that the central idea in all was service to agriculture and to rural people. These institutions were not established primarily in the interests of science *per se,* but were established in order that the methods of science and of scientific research might be applied to the solution of the problems of agriculture. How well these institutions have accomplished their purposes is a matter of general knowledge. Thru their work there has been brought to the service of agriculture the highest scientific ability utilizing the most modern equipment necessary for research, and thus providing for the industry of agriculture the same aids to production that have been available to other industries thru industrial research.

Now, after fifty years of active and significant service to mankind, we are profiting from the results of the work of agricultural experiment stations in improved quality of farm products, reduced costs of production, improved varieties of plants and breeds and races of animals, in the prevention and control of animal and plant diseases, and have in the state agricultural experiment stations of the United States an organization of individuals of the highest scientific training available, equipped with apparatus, materials and supplies which combined constitute one of the most important agencies for scientific research in the world. We may regard these organizations and institutions as representing one of the most effective instruments for the solution of peace-time problems. With the help of these institutions agriculture is prepared to meet the difficult problems of the future.

It is not any part of the purpose of this brief discussion to recount the definite achievements of agricultural experiment

stations. The value of the results of scientific research in these institutions is generally recognized. The experiment stations have been remarkably successful in meeting the problems of agricultural production as they have developed, and are in a position to continue to solve such problems in so far as science and research can accomplish such solutions.

It may not be inappropriate on this occasion to give some brief consideration to the future of the agricultural experiment station. What is to be the future of American agriculture? Are we traveling in the right direction? Is this industry of agriculture—the oldest, most permanent, and enduring of all industries—to be replaced in whole or in part by a factory system? Is it conceivable that future food and fibers, for feeding and clothing mankind, will be supplied by synthetic products made in factories?

In the August issue of Harper's Magazine, Parrish and Clark, writing under the title, "Chemistry Wrecks the Farm", have developed the thesis that the cultivation of the soil and the production of food, feed, and fiber on farms will become a thing of the past, as other industries have passed out of the picture due to the application of the results of scientific research. I quote from this article: "The farm as an individual production unit * * * is seeing its last days. For chemistry and technology are bringing agriculture under control." Again, "It would be relatively easy to produce the 1930 crops with only five per cent of the (farm) population." In a prophetic vein the development of agriculture and its probable decline, the third stage is described as follows: "Control stage, which eliminates the soil as being unnecessary to plant growth. Plants are grown in a solution of necessary organic substances in trays or cabinets with a new crop every few weeks. This stage takes agriculture off the farm into factories or kitchens and places it under strict man-made control."

I have quoted sufficiently from the article to indicate the tenor and conclusions of the authors. There are so many assumptions in this article which can not be verified or confirmed by results of actual investigations that any extended discussion at this time probably would be of little interest. However, great as have been the achievements of chemistry, there is no

adequate basis for the assumption that five percent of the present farm population could satisfy the demands for food and fiber crops of our present population, to say nothing of the probable population increases.

It also is pertinent to inquire as to the source of the materials which are to be synthesized in the production of food, feed, and fiber. There must be raw materials from which such products could be made and these must be taken from the air or the soil, which means that even if the remarkable development described in this article were remotely possible, there still would be required a great volume of raw products, which must come from the soil. At no previous period in the world's history have the cultivators of the soil had so complete control over factors of production. Scientific research is now and will continue to be the most effective instrument for stabilizing agriculture, and is not now and will not become a weapon for its destruction.

We must continually recall to our minds the permanency of agriculture. The cultivation of the soil is the oldest human occupation. It represents the beginnings of civilization and continues to represent the most stable and permanent element in our civilization. History records the decline and ultimate destruction of many of the greatest cities built by man; governments have flourished and have perished, but the cultivation of the soil and the maintenance of the farm home continue as the most permanent and secure single economic and social factors in our civilization. Some time ago the French government offered a prize to the family having continued to live longest on one farm. The prize was awarded to a family whose ancestors had lived on and owned the same farm for a thousand years. During this period the country had been invaded a score of times, kingdoms had changed to republics and republics to dictatorships and back again to republics; but this family, on its own farm, with its own agricultural enterprise, had continued secure in its possession of land and the facilities for production.

Agriculture and farming continue to offer the most secure, the most permanent, and in many ways the most satisfying type of living, not only in this country but thruout the world.

ALFRED MEREDITH PETER, Sc. D

Acting Director of the Kentucky Agricultural Experiment Station, 1916-1917.

Farming is not only a business motivated by economic returns, but it is a way of living. The farm and the farm family represent a stable and permanent social unit in our civilization on which can be builded a permanent governmental structure. The nation can not afford to ignore certain values peculiar to rural life. Without these values a nation is in very real danger.

It is the primary function of the agricultural experiment station to maintain these permanent values and to make the business of farming a safer and more remunerative and a more satisfying occupation. One by one the risks and vicissitudes surrounding the farmer and his work are being removed by scientific research in the agricultural experiment stations. Destructive animal diseases are largely under control thru the work of these institutions; insect and fungus diseases of plants can be controlled, and in many cases entirely prevented. The adaptation of crops to special soils, the improvement of plants thru the efforts of plant breeders, and the improvement of the quality of all farm products are outstanding achievements of the agricultural experiment stations.

A Planned Agriculture. If agriculture as an industry is to become stabilized and farmers as a class are to be assured even a minimum standard of living, some further effort must be made in the direction of national planning. There is nothing essentially new or startling about the idea of national planning. It does, however, involve the idea of a greater emphasis on governmental relation to the factors of production and the utilization and distribution of agricultural products. The policies of the federal and state governments have from the very beginning exercised a compelling influence upon agricultural development. They will continue to do so. For more than fifty years the most important single governmental policy affecting the agricultural industry was the practically free gift of land under the homestead act. As a result of this policy farmers were influenced to settle upon and develop not only land of agricultural value but millions of acres of marginal and submarginal land entirely incapable of providing even a minimum standard of living worthy of our American tradition.

If the federal government had based this far-reaching land policy upon a well-planned classification of soils, we would not now be facing the necessity of resettling stranded populations and instituting a policy of buying back land from misguided settlers. We have too long proceeded on the theory that all land was agricultural land and should be occupied and developed. We must now retrace our steps and inaugurate a policy which is entirely different from, if not opposed to, this conception. Land of limited agricultural value may be very desirable for forestry, for recreation, for wild-life reservations, or in some cases for use in the control of floods and watershed erosion. We do not yet have an adequate scientific basis for a classification of soils of sufficient refinement to meet fully the ultimate requirements and serve as an accurate guide in developing a permanent policy of resettlement. This is a problem for the agricultural experiment station and can be solved.

There is apparent in some quarters a disposition to hold science and research responsible for our current economic distress. It has been suggested that "science take a holiday". We are accused of knowing too much. It is said that science and discovery have so accelerated our progress over the control of our physical environment that we are now able to produce more of everything than can possibly be utilized by the present population of the earth. The argument seems to be that because science has had so outstanding a success in the fields of its chief endeavors it is now criticized because it has not solved all the complex problems of human relations.

In the past we have left to the preacher and the politician the development of those social controls which influence human relations and are of the utmost importance in human living. Has the time come when the scientific method can be applied to the solution of social problems? Are right living and a good life subjects for scientific research? Is the development of righteousness a function of scientific research?

It is, I think, clear to all thinking men and women that as a result of the applications of scientific research, control of our environment is far more complete than our control over human relations. I think we must recognize that there are "things of

the spirit'' which are not now and may never be amenable to scientific research as we now understand the term. All scientific research must have for its ultimate goal the welfare of the human race. It is possible, as someone has suggested, that we may do something more in the direction of humanizing science, and this suggests more and more attention to social and economic problems. This still will leave us with the problem of human character. The measure of the value of scientific research will be determined by the use of its results by human beings. It must be recognized that the results of science may be used by vicious individuals for purposes inimical to human welfare, but this is not to be used as an argument against further scientific research but rather to emphasize the fundamental importance of the development of moral controls.

Is the agricultural experiment station responsible for the conditions which have brought about the present agricultural depression? The argument sometimes is advanced that thru the efficient work of the agricultural experiment stations the efficiency of farmers has been so greatly increased that a smaller number of farmers is now able to produce a greater total product. By reason of this they have been encouraged to overproduce and thus accumulate a surplus of food and fiber crops. This surplus has decreased the price of farm commodities and the result is a lower farm income. Any thinking person can readily discover that there is little basis for this conclusion. In the first place, the American farmer's surplus, if it exists, is due to the almost complete closing of foreign markets to American Agricultural products. This alone would be sufficient to explain the surplus, but the farmer's feverish effort to produce has resulted from a deeper cause. After the inflation period, followed by a sharp deflation, the farmers of America found themselves deeply in debt. The diminishing prices of farm products, descending to a record low in 1932, made it necessary for the farmer to produce the largest possible number of farm units to meet his interest charges, taxes, and other requirements. The invention of labor-saving farm machinery made it possible for fewer farmers to produce more products and this the farmer was forced to attempt, not because of any work of the agricultural experiment stations but because of the closing of world markets, the sudden

GEORGE ROBERTS, M. S.

Acting Dean of the College of Agriculture, 1916-1917; Assistant Dean, 1919—

change in the monetary standard, and the resulting widespread indebtedness.

The agricultural experiment station pleads guilty to having aided the farmer in increasing his efficiency; by increasing his efficiency it aided him to decrease the cost of production of all farm commodities. The experiment station has made it possible for the farmer to secure a larger farm income on a smaller acreage and with less labor.

The difficulties of the farmer under present conditions seem to be largely economic and governmental, and while agricultural experiment stations may contribute to a knowledge of the workings of economic law and the influence of governmental policies, it is not the province of the experiment stations to undertake to interfere with national and international economic policies and governmental activities. These are problems which can be solved only by the farmer himself, organized to protect his own interests and faithful to the traditions of the agricultural industry.

The farmer's problems capable of solution by scientific research are not all solved. More and more difficult problems of greater complexity continue to arise. The possibilities of further contributions to agriculture by the experiment stations are incalculable. The possibilities in this direction are infinite.

And now, in conclusion, if we may dare to extend our vision to the illimitable reaches of time and space and in wonder and imagination construct for our minds the possibilities of achievement thru research, we may conclude with Sir James Jeans that our achievements of the past are to the possibilities of accomplishments in the future as is the thickness of a postage stamp to the height of Mount Blanc. I close by quoting from the same author:

"As inhabitants of the earth we are living at the very beginning of time. We have come into being at the fresh glory of the dawn and a day of almost unthinkable length stretches before us with unimaginable opportunities for accomplishment. Our descendants in far-off ages, looking down this long vista of time from the other end, will see our present age as the misty morning of the world's history. . . . By what light we have, we seem to discern that the main message . . . is one of

hope to the race and of responsibility to the individual—of responsibility because we are drawing plans and laying foundations for a longer future than we can well imagine."

After Dr. Mumford's address, President McVey introduced Professor E. S. Good, Head of the Animal Industry Group, who, as introductory to unveiling and presenting a portrait of Dean Thomas P. Cooper to the University, said:—

We are often told by eminent thinkers and speakers, that we are living in a wonderful age of scientific research and discovery. However, it takes a program like the one this afternoon, a resume of the development of agriculture in the last fifty years, to make us appreciate how great a contribution scientific agriculture has made to this forward movement of research and discovery.

We have seen, this afternoon, the foundation work of Dr. Scovell, which was carried on at a time when scientific agriculture was in its pioneer stage. We have seen the emphasis placed upon research, which Dr. Kastle was particularly fitted by training and temperament to foster. As changing conditions demanded a man not only cognizant of the great value of research but one with special training in the economics of agriculture, in farm organization and management and extension, the College of Agriculture and Experiment Station of the University of Kentucky were most fortunate to secure Thomas Poe Cooper as Dean and Director. Upon the recommendation of President McVey he was appointed to his present position in 1917 and in January, 1918, Dean and Mrs. Cooper came to Kentucky.

As far as I know, Dean Cooper has never engaged in any other occupation than one relating to Agriculture. As a young man he managed farms. After graduating from the College of Agriculture of the University of Minnesota, he was placed in charge of a research project in cost accounting in the Division of Agronomy and Farm Management of that institution, and the results were published. Gaining insight into the value of specific farm organization from this work, he was placed in charge of a group of demonstration farms. This marked the beginning of extension work in Minnesota. Because of the capable way in which he handled this work, attracting the attention not only of the farmers of Minnesota but of neighboring

states as well, he was appointed head of The Better Farming Association of North Dakota. After two years in this position, he became the Director of the Experiment Station and Extension work in the North Dakota Agricultural College.

During his regime in North Dakota he changed the system of farming in that state from one of almost exclusive small-grain farming to a diversified one, emphasizing a larger acreage of alfalfa, soil and pasture improvement, increased livestock production and enlarged experimentation.

Dr. Andrew Boss, now Vice-Director of the Agricultural Experiment Station of the University of Minnesota, one of the most beloved and respected men of his profession, a former teacher of Thomas Poe Cooper, says of his pupil's ability and work during these years. "Director Cooper's keen business insight, his habits of thrift and industry, and his ability to keep in touch with the many lines of work and many different people, enabled him to initiate new trends in agriculture in Minnesota, and to re-direct in a large measure the farming operations in North Dakota. Dean Cooper merits great credit for initiating and developing many of the good farm management practices now in effect in these states."

Since coming to the University of Kentucky in 1918 Dean Cooper has needed all his training and experience as an executive and economist, for he has guided the Agricultural College and Experiment Station thru the post-war period of adjustment; the succeeding period of overexpansion, and the last few years of depression, with a caution and wisdom that has kept us on an even keel in spite of the storms. Because of his national reputation as an agricultural economist, he was offered the position of Chief of the Bureau of Agricultural Economics, U. S. Department of Agriculture, which position he declined to accept permanently. However, the Board of Trustees, appreciating the honor of such an appointment, granted him a years leave of absence in 1926-27 that he might assist the Secretary of Agriculture during a transitory period of reorganization in that bureau.

Because of this same reputation he served as chairman of a special committee of The Association of Land Grant Colleges and

ADAM PEPIOT, PHOTO

HENRY ERNEST CURTIS, M. S.
Chemist, 1887.

Universities to prepare and submit reports in 1927 and again in 1932, on The Agricultural Situation in the United States. He has served as Secretary-Treasurer of this Association since 1930. Dean Cooper is a past president of The American Farm Economics Association and of The Association of Southern Agricultural Workers. Time does not permit my going into further detail as to organizations to which Dean Cooper belongs, and honors and responsibilities which have been and are his. However, we must mention that here in Kentucky, in addition to his regular duties, he is Vice-Chairman of the Kentucky Board of Agriculture, Vice-Chairman of the Kentucky Livestock Sanitary Board, a member of the Kentucky State Parks Commission, a director in the Federal Land Bank of Louisville and its affiliated organizations, and a director of the Central Bank for Cooperatives.

Since Dean Cooper came to the University of Kentucky in 1918 the physical plant of the Experiment Station has been enlarged to a considerable extent. Three hundred and fifty-seven acres of land, much needed for expanding experimental investigations, have been added to the Experiment Station farm. New Buildings, including a Livestock Pavilion, a Dairy Manufactures Building, a Farm Engineering Building, and several new barns have been added. These were very much needed for effective teaching and experimental work.

Of great importance in developing the agricultural possibilities of Kentucky, and studying types of agriculture for different localities, was the establishment of two agricultural Substations. One at Quicksand, in eastern Kentucky, comprising some 15,000

acres, was the generous gift of the late E. O. Robinson. The other, comprising 600 acres, is located at Princeton, Caldwell County, in western Kentucky.

Co-workers in an institution such as ours, show their appreciation of the man who guides and directs their activities by co-operation, in pride of accomplishment, and in an attitude of good-will. Such we feel is the spirit of our institution and a thing apart from its physical development. Such a spirit is the influence of Dean Cooper upon his co-workers, and it is because of this spirit that we have united in a desire to express our appreciation of Dean Cooper's fine leadership and accomplishments, thru the presentation of his portrait to the University of Kentucky.

HARRISON GARMAN, Sc. D.
Entomologist and Botanist, 1889—

Fortunate indeed are we that for eighteen years we have had the guidance of a man of such personal integrity, such unwavering devotion to work, and unswerving loyalty to co-workers; a man of foresight, courage and decision, and an executive commanding respect and confidence. If the artist has been able to transfer these qualities to the canvas he is a great artist indeed. Sudduth Goff, formerly of Lexington, now of Chicago, a portrait painter of international reputation, has made this portrait of Dean Cooper.

Professor Good called upon Miss Catherine Corter Cooper who came to the platform and unveiled the portrait.

After the unveiling, Professor Good presented the portrait to President McVey for the University of Kentucky in the following words: "I have the honor, on behalf of the staff of the College of Agriculture, to present this portrait of Dean Cooper to the University of Kentucky."

President McVey accepted the portrait for the University.

President McVey then stated that when, in 1885, the Kentucky Agricultural Experiment Station was established, in addition to the Director there were six members of the staff. Of this number three had been in continuous service for the intervening years and were in the audience. He then asked A. M. Peter, H. E. Curtis and H. Garman to come to the platform and on behalf of the staff presented each with a handsome cane as a token of love and esteem and for their long and distinguished service to the institution.

Reverend T. E. Ecton pronounced the benediction.

Letters of felicitation, friendship and good will on the occasion of the Fiftieth Anniversary of the founding of the Experiment Station, were received from sister institutions, co-workers and friends, as follows:

State of Alabama, Department of Agriculture. Geo. H. Marsh, Supervisor, Division of Agricultural Chemistry.

Alabama Polytechnic Institute. J. C. Grimes, Head Animal Industry Group.

Alabama Polytechnic Institute. L. N. Duncan, President.

Colorado State College. The governing board and the faculty, by Chas. A. Lory.

The Connecticut Agricultural Experiment Station. William L. Slate, Director.

Centre College. Charles J. Turck, President.

University of California, College of Agriculture. C. B. Hutchison, Dean.

The Agricultural Experiment Station, Colorado State College. E. P. Sandsten, Dean and Director.

Cornell University, Ithaca, N. Y. A. R. Mann, Office of the Provost.

University of Delaware, Agricultural Experiment Station. C. A. McCue, Dean and Director.

Eastern Kentucky State Teachers College. H. G. Donovan, President.

Agricultural Experiment Stations of the University of Florida. Wilmon Newell, Director.

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Kentucky
Agricultural Experiment Station

University of Kentucky

THOMAS P. COOPER, Dean and Director

The First Season's Growth of Apple Grafts as Affected by Type of Stock and Part of Cion.

CIRCULAR NO. 49

Lexington, Ky.
February, 1938

SUMMARY

1. A total of 767 apple grafts were made in February of 1936 composed of 34 different varieties. The cion wood was selected so that it was fairly uniform in length and diameter. There were 268 piece root whip grafts made, using the basal half of cion wood, 270 using the tip half, 103 whole root grafts with basal half of cion wood, 107 using the tip half and 19 piece root grafts on which whole cions were placed. The grafts were grown for one season and the height in inches and the diameter in sixteenths of an inch were carefully taken after growth for the season had been completed.

2. Comparisons between groups of grafts were made as to total mortality, small trees, good trees, height and diameter, and calculations were made to test the mathematical significance in these comparisons.

3. The percentage mortality was considerably greater with piece-root than with branched whole-root stocks.

4. As good results were obtained by using the tip half as by using the basal half of the cion.

5. The number of small trees resulting from the different combinations of cion and root was nearly the same in the different groups.

6. There was no significant difference in either height or diameter of trees in the different groups. This appears to indicate that if a cion grafted to a piece root starts growth satisfactorily, it stands just as good a chance of producing a nursery tree of good size in both height and diameter as one grafted to a branched whole root.

7. There were some differences in the response of different varieties as to mortality of grafts, independent of the type of stock used.

8. A high degree of correlation was found between height and diameter of trees.

CIRCULAR NO. 49

The First Season's Growth of Apple Grafts as Affected by Type of Stock and Part of Cion.

By C. S. WALTMAN

Plan of Work. Much has been written regarding the use of whole-root and piece-root grafts in the propagation of apples and there seems to be a general agreement that trees on whole roots are likely to show better growth in the nursery. This advantage may continue for a few years after the trees are planted in the orchard but after growing for several seasons the differences between trees propagated on piece and whole root stocks disappear and one is usually found to be just as satisfactory as the other.

In the choice of cion wood practically all investigators (11, 2, 6, 12) recommend the use of fairly vigorous, well-matured wood of the past season's growth. In addition to this, the statement is commonly made that the central portion of the cion generally produces the best results. The buds on the basal portion of a cion frequently are weak, while the wood at the tip is likely to be too soft and immature to produce good grafts.

To test whole-root versus piece-root grafts, and the top and lower half of cion wood, 767 whip grafts were made in February of 1936 from 34 varieties of apples. The cion wood was chosen so that all pieces were fairly uniform in length and diameter and each cion piece was cut into 2 equal parts so that the upper half and lower half were used both on branched whole-roots and on straight, unbranched piece-roots of French Crab seedlings. The cions were made 7 to 8 inches in length and the stocks 4 to 5 inches. The summer of 1936 was very dry and this necessitated watering the young trees at intervals as their requirements

demanded. The water was applied as uniformly as possible with a rotary sprinkling device over the area occupied by the trees. The number of grafts of each type, the varieties of apple and the results of the tests are given in the tables.

TABLE 1. NUMBER AND KIND OF GRAFTS MADE WITH EACH VARIETY OF APPLE.

Variety	Whole Root		Piece Root		Variety	Piece Root		
	Basal half of cion	Tip half of cion	Basal half of cion	Tip half of cion		Basal half of cion	Tip half of cion	Whole cion
Turley	25	25	50	50	Orleans	6	6	
Nero	5	5	5	5	Kendall	6	6	
Stayman	6	6	6	6	Staymared	6	6	
Delicious	5	5	5	5	Fameuse	6	6	
Smokehouse	6	6	6	6	Medina	6	6	
Gravenstein	8	8			Milton	6	6	
Winesap	5	5	5	5	Early McIntosh	5	5	
Paducah	5	5	5	5	Starking	10	10	
McIntosh	6	6	6	6	Lodi	6	6	
Golden Delicious	25	25	25	25	Macoun	6	6	
Polly Eades	7	11	21	21	Fyan	5	6	
Hubbardston			10	10	Fourot	7	7	
Black Ben Davis			6	6	Wright	7	6	
Carson			7	8	Conard	5	5	
Rome Beauty			8	8	Grove	3	4	
Wagener			6	6	Fallwater			15
Newfane			7	7	Whetstone			4
Total	103	107	Fd.	Fd.		268	270	19

Discussion. The results of these tests indicate that the principal advantage to be gained by the use of branched whole-root stocks in comparison with piece roots, is in the lower mortality of grafts after they are set in the nursery row. There was no significant difference in the height or diameter measurements of nursery trees produced by grafts of the various types as shown by Table 4.

In Missouri (11) tests with Jonathan trees that were propagated in 1889 on piece and whole roots were grown until 1920. Practically no differences were found in total yield or in the character or quality of the fruit produced. Also, by the time the trees were thirteen years old there was no appreciable difference in their size. Chandler (3) states that reports from Alabama,

TABLE 2. EFFECTIVENESS OF THE GRAFTS AS SHOWN BY THE NUMBER DEAD AND GROWTH OF THE SURVIVORS THE FIRST SEASON.

	Whole root		Piece root		Whole cion	All kinds
	Lower half of cion	Upper half of cion	Lower half of cion	Upper half of cion		
Dead	22	19	99	115	6	261
Under 20 inches high	6	4	8	4	2	24
Good	75	84	161	151	11	482
Total	103	107	268	270	19	767
Average height, inches	39.75±.45	38.84±.68	40.54±.43	42.04±.26	31.54±.77	38.55
Average diameter in sixteenths of an inch	5.70±.09	5.54±.11	5.95±.06	6.03±.06	5.92±.27	5.83
Percent dead	21.4	17.8	36.9	42.6	31.6	34.0
Percent under 20 inches high	5.8	3.7	3.0	1.5	10.5	3.1
Percent good	72.8	78.5	60.1	55.9	57.9	62.9

TABLE 3. AVERAGE HEIGHT, DIAMETER, AND NUMBER OF LIVING TREES, GROUPED ACCORDING TO HEIGHT.

Group as to height	Whole root		Piece root		Whole cion
	Lower half of cion	Upper half of cion	Lower half of cion	Upper half of cion	
	Average height in inches.				
Under 20"	16.50	16.00	17.40	15.67	16.50
20"–30"	26.50	25.00	24.29	22.88	22.50
30"–40"	35.20	34.83	35.70	35.67	36.00
40"–50"	43.33	43.00	43.40	43.90	43.00
50"–60"	53.80	53.25	52.78	56.67	.....
60"–70"	61.00	60.50	63.67	62.50	.....
	Average diameter in sixteenths of an inch.				
Under 20"	3.50	3.00	3.40	3.33	3.50
20"–30"	4.50	4.35	4.17	3.59	4.50
30"–40"	5.23	5.04	5.32	5.25	6.40
40"–50"	6.10	6.24	6.39	6.26	8.00
50"–60"	7.15	7.13	7.49	7.35	.....
60"–70"	7.50	7.50	8.56	8.70	.....
	Percent of the number of live trees.				
Under 20"	3.70	2.35	4.14	3.20	15.38
20"–30"	9.88	17.65	9.47	9.61	23.08
30"–40"	37.04	30.60	30.77	23.72	38.46
40"–50"	28.39	31.76	37.28	37.82	23.08
50"–60"	18.52	15.29	15.36	21.80	.....
60"–70"	2.47	2.35	2.96	3.85	.....
Number of live trees	81	85	169	156	13

Pennsylvania and Oregon indicate that trees grown from piece-root grafts, whether the top or bottom piece of a long root was used, gave as good results in the orchard as trees produced on whole-root stocks. Mason and Jones (7), reporting from Kansas on several years' work done in grafting apples, obtained results similar to those stated above. No lasting benefit was secured by using whole root stocks. The Kansas report also states the experience of Judge Wellhouse who propagated 30,000 apple trees with various types of grafts. In this work he used 3 varieties and grew 1800 on whole roots and 7200 on piece roots, using varying lengths of root stocks. Several hundred of these nursery trees were planted in a permanent orchard and the grower found no difference in the various trees after 19 years, except those from piece-root grafts where three-inch, two-inch and one-inch root stocks were used rooted freely above the graft union which

was a desirable characteristic. The trees on whole-roots and those on piece-roots where the root stock was longer than three inches formed no roots from the cions. Another condition noted was that the trees on whole roots threw up more sprouts from the root system than occurred from the others.

Investigators in Europe (1, 5) and in Kansas (7) found great differences in growth rates and general vigor as well as wide variations in character of growth and in the root systems of seedling grown from French Crab seed. Sax and Gowen (10) presented statistical proof to show that weak stocks are the principal cause for small, low-yielding trees in an orchard. That the soil was not the principal factor in determining size and yield of trees was shown by the fact that, in the case of isolated weak trees, though not with groups of weak trees, the roots of adjacent more vigorous trees were growing among the roots of the weak ones and the reverse of this was also found. In other words, roots of weak and vigorous trees were growing in the same soil. In Wisconsin, Roberts (9) found that large stocks produced larger trees but that the cion differences appeared to produce more variation in the nursery trees than did the stock differences. He found that the large size was quite consistently and closely related to the earliness of growth of the cion variety, and that the cion variety changed the root character of the seedling stocks very greatly.

Gardner and Yerkes (4) found that small seedlings increased as rapidly as larger ones and that small seedlings were small when purchased from the seedling grower largely because of environmental factors rather than inherent lack of vigor. They found a general trend for large stocks to produce trees of large diameter but found no increase in height of whip as a result of grafting on large seedlings.

Whether the basal or the tip half of the cion was used on either a branched whole root or a piece root seemed to make little difference in the ultimate growth which the trees in this test made during the first season but regardless of the portion of cion used, the mortality of grafts on piece roots was much greater than that of grafts on branched whole roots. In grafting work

done in previous years but heretofore unreported, similar results were obtained in the comparative mortality percentages of branched whole-root and piece-root grafts. In summers favorable for growth, however, the trees from whole-root grafts usually showed better growth in the nursery row than those from piece-root grafts of the same variety. Watering was not resorted to in the previous work.

The percentages of mortality and of good trees, shown in Table 2, present rather striking differences in the results obtained between piece-root and whole-root grafts but comparatively small differences between the basal and tip halves of the cion wood, regardless of the kind of stock used.

The percentages and the average height and diameter measurements alone do not indicate the significance in variation between groups on different stocks or between those on the same kind of stock. As a means of testing the significance in variation between the different percentage figures and also between the height and diameter measurements of the various trees, the procedure as shown by Peters and Van Voorhis (8) was followed.* The results are presented in Table 4.

---

* The following formulas were used:

$$\sigma_{p_1-p_2} = \sqrt{\frac{p_1 q_1}{N_1} + \frac{p_2 q_2}{N_2}}$$

where

p_1 and p_2 = the percentages between which the difference is to be tested.
$q_1 = 100 - p_1$
$q_2 = 100 - p_2$
N_1 and N_2 = the number of grafts in each group.

$$\sigma_{m_1-m_2} = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}$$

where

m_1 and m_2 = the means between which the difference is to be tested
σ_1 and σ_2 = the standard deviation of the measurements for each group.
N_1 and N_2 = the number of grafts in each group.

TABLE 4. DIFFERENCE BETWEEN AVERAGE FINDINGS FOR THE SEVERAL KINDS OF GRAFTS, AND STANDARD ERRORS OF THESE DIFFERENCES.

Comparisons	Percent dead		Percent small		Percent good		Height, inches		Diameter, sixteenth of an inch	
	Difference	Stand. error	Difference	Stand. error	Difference	Stand. error	Difference	Stand. error	Difference	Stand. error
Piece root, base vs. piece root, tip	5.70	4.20	0.77	1.27	4.93	4.24	1.50	2.23	0.08	0.39
Piece root, base vs. whole root, base	15.58†	5.00	0.31	1.92	15.30*	5.17	0.79	2.77	0.20	0.49
Piece root, base vs. whole root, tip	18.67†	4.80	0.69	1.66	19.36†	4.94	1.70	3.56	0.41	0.55
Piece root, base vs. piece root, whole cion	5.36	11.06	7.92	7.11	2.56	11.72	9.00	8.08	0.03	1.49
Piece root, base vs. total number	2.74	3.41	0.13	1.12	2.87	3.46				
Piece root, tip vs. whole root, base	21.28†	5.05	1.07	1.85	20.21†	5.19	2.29	2.33	0.33	0.49
Piece root, tip vs. whole root, tip	24.37†	4.83	0.08	1.57	24.29†	4.96	3.20	3.24	0.49	0.54
Piece root, tip vs. piece root, whole cion	11.06	11.08	8.69	7.09	2.37	11.72	10.50	7.94	0.11	1.49
Piece root, tip vs. total number	8.44	3.45	0.64	0.99	7.80	3.48				
Whole root, base vs. whole root, tip	3.09	5.54	0.99	2.13	4.08	5.77	0.91	3.63	0.16	0.62
Whole root, base vs. piece root, whole cion	10.22	11.40	7.62	7.23	17.84	12.09	8.21	8.11	0.22	1.52
Whole root, base vs. total number	12.84*	4.39	0.43	1.75	12.41*	4.57				
Whole root, base vs. piece root, whole cion	13.31	11.32	8.61	7.17	21.92	11.99	7.30	8.41	0.38	1.54
Whole root, tip vs. total number	15.93†	4.16	0.56	1.46	16.49†	4.30				
Piece root, whole cion vs. total number	2.62	10.80	8.05	7.11	5.43	11.46				

* Practically significant. † Significant.

Unless the difference between the percentages in any two groups under consideration was at least three times the calculated standard error of the difference, it was not considered significant. Similar tests of significant difference between average height and average diameter measurements were used. (8)

There was no significant difference in the percentage of small trees between any of the groups of grafts. Even though the percentage of small trees for the group of piece root whole-cion grafts was considerably more than for the other groups, it was not significant because of the small number of trees in this group.

In the percentage of mortality and the percentage of good trees, Table 4, the branched whole-root grafts were significantly different from the piece-root grafts, regardless of the portion of cion used. The mortality percentage was significantly smaller and the percentage of good trees significantly greater for both groups on whole-root stocks. It is of further interest in this connection that the percentage mortality of grafts on whole roots lacked only a fractional amount of being significantly less than that of the total number of grafts made. Since the figure taken to indicate significance is one of arbitrary choice, practically the same significance holds true for the percentage of good trees in the two groups of whole-root grafts. This is to be expected, however, in view of the fact that their mortality was lower and the percentage of small trees practically the same. The two places where the rule of significance does not hold completely true in the column representing "Percent good trees" is for the comparisons of piece root, basal vs. whole root, basal and whole root, basal vs. total number. In these two cases, however, the difference between the groups under comparison is so near to three times the standard error that the difference may be considered as of practical significance.

There was no significant difference, in fact, comparatively little difference, in the height and diameter measurements of trees in the five graft groups. It appears evident that there is a definite positive correlation between height and diameter for

the trees in the different groups. The correlation coefficients for each group are presented in Table 5.

TABLE 5. CORRELATION OF HEIGHT AND DIAMETER OF TREES GRAFTED IN DIFFERENT WAYS.

Kind of graft		
Root	Cion	Correlation coefficient
Piece	Basal half	.77±.02
Piece	Tip half	.80±.02
Whole	Basal half	.75±.03
Whole	Tip half	.74±.03
Piece	Whole cion	.70±.10

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